NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-SAS-066**

Joint Operations 2030 – Final Report

(Opérations interarmées 2030 – Rapport final)

This Report documents the methodologies and findings of the NATO RTO SAS-066, Joint Operations 2030 Long-Term Scientific Study.

Published April 2011

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This Report documents the methodologies and findings of the NATO RTO SAS-066, Joint Operations 2030 Long-Term Scientific Study.

The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Executive Summary

Long-Term Scientific Studies (LTSSs) have generally been initiated in 10 – 15 year cycles: the last such effort included LTSSs on Land, Air and Maritime Operations that were conducted in the mid 1990s. In 2006 the Systems Analysis and Studies (SAS) Panel of the NATO Research and Technology Organisation approved the conduct of a new LTSS, SAS-066, on Joint Operations in the year 2030 otherwise known as the "Joint Operations 2030 Study".

During its three year mandate, the study attracted intermittent participation from close to half the NATO nations, steady participation from 8 NATO Nations and agencies, and produced three main outputs:

- An explorative Thematic Analysis approach that can be used to complement current defence planning efforts;
- The JO 2030 Capability Set; and
- A set of List One Technology Focus Areas and associated Fields of Science that merit consideration for future research and technology investment.

The first major output, the Thematic Analysis approach, employed a series of creative spirals to develop a set of 18 Joint Operations 2030 Themes. These Themes defined a thought space that was used to examine future capability requirements. They were meant to be thought provoking and to be clearly separate from well-studied trends that many experts have already agreed will have an impact on future operations. The Thematic Analysis approach was a deliberate effort not to validate the well-known problems of tomorrow but rather to explore the not so well-known challenges that may develop or evolve with time.

The second major outcome, the JO 2030 Capability Set, was built up from the 18 Themes that were elaborated into 60 Issues and associated with 114 Capabilities – the end result is a set of 355 Theme-Issue-Capability (TIC) triplets that constitute the JO 2030 Capability Set. This set of capabilities incorporated the 38 Long-Term Capability Requirements from Allied Command Transformation's Long-Term Requirement Study and contain a range of traditional, warfighting capabilities through to some challenging capabilities which would not be found in current day Capability Based Planning capability sets.

The JO 2030 Capability Set was prioritized into three sub-sets or lists. In an attempt to provide the best return for effort, the study focused on the List One Set of TICs which were a smaller set of 40 Theme-Issue-Capability triplets that the study considered would benefit from an improvement in level of capability, are important to future NATO operations, but are not currently an area of active research by most NATO Nations. This generated the third major output of the study – the set of List One Technology Focus Areas. Working with a variety of research efforts, the JO 2030 Study compiled a list of 247 Technology Focus Areas. This list of Technology Focus Areas, at first look, point broadly towards the need to investigate or seek advancement in:

- Many areas of social science research;
- Algorithmic development;
- Exploiting ongoing commercial advances across a number of technologies; and
- Understanding the strengths and limits of human cognition.

A second level analysis of the Technology Focus Areas resulted in their association with one or more Fields of Science, the top five most frequently associated Fields of Science being:

- Computer sciences;
- Engineering;
- Systems science;
- Management; and
- Formal sciences.

This list of the associated Fields of Science, constitute the best indications of areas of research investment that, in turn, may advance possible solutions to the most challenging capabilities that lay ahead for the NATO Nations in the coming years, as identified by the JO 2030 Study. In this context it is important to understand that the most challenging capabilities are capabilities that were not well understood as problems that needed addressing; they were not thought to be part of an active research interest from many of the NATO Nations; and, they, in many cases, are problems that may never have a correct or acceptable resolution point. As well, it should be clearly understood, that this list of the top Fields of Science doesn't imply any inherent prioritization of these areas of research in comparison to other already ongoing efforts. This was a consideration that was left to a future effort.

Opérations interarmées 2030 – Rapport final

(RTO-TR-SAS-066)

Synthèse

Les Etudes Scientifiques à Long Terme (LTSSs) ont généralement été lancées sur des cycles de 10 à 15 ans : Le dernier chantier comprenait les LTSS sur les opérations Terrestres, Aériennes et Maritimes conduites dans le milieu des années 1990. En 2006, le Panel sur les études et les analyses de systèmes de l'Organisation pour la Recherche et la Technologie de l'OTAN donna son accord à la conduite d'une nouvelle LTSS, SAS-066, sur les Opérations interarmées en 2030, connue sous le nom « Joint Operations 2030 ».

Pendant son mandat de trois ans, l'étude nécessita la participation jusqu'à près de la moitié des nations de l'OTAN, et la participation constante de 8 nations et agences de l'OTAN, et produisit trois principales réalisations :

- L'approche d'une analyse thématique exploratoire utilisable pour compléter les travaux actuels de planification de défense ;
- L'ensemble capacitaire JO 2030 ; et
- Une série d'aires de convergences technologiques de Liste Une et les domaines scientifiques associés qui méritent d'être retenus pour les futurs investissements de recherche et de technologie.

La première réalisation, l'analyse thématique, utilisa une série de spirales de créativité afin de développer un éventail de 18 thèmes sur les opérations interarmées 2030. Ces thèmes ont délimité un espace de réflexion qui a servi à examiner les futurs besoins capacitaires. Ils devaient être volontairement provocants et clairement différents des courants bien connus, que de nombreux experts avaient déjà identifiés comme ayant une incidence sur les opérations futures. L'analyse thématique constituait un effort délibéré non pas pour valider les problèmes bien connus de demain, mais plutôt pour explorer les challenges bien moins connus qui peuvent se développer ou évoluer avec le temps.

La seconde réalisation importante, l'ensemble capacitaire JO 2030, a été constitué à partir des 18 thèmes qui furent déclinés en 60 questions et associés à 114 capacités: le résultat final est une panoplie de 355 tripodes Thème-Question-Capacité (TIC) qui constituent l'ensemble capacitaire JO 2030. Cet ensemble de capacités a englobé les 38 exigences capacitaires à long terme de l'étude correspondante du Commandement Allié pour la Transformation et contient un éventail de capacités de combat, dont certaines capacités provocatrices que l'on ne pourrait pas trouver dans les ensembles actuels de planification sur base capacitaire.

L'ensemble capacitaire JO 2030 a été hiérarchisé en trois sous-ensembles, ou listes. Pour tenter de fournir le meilleur retour pour ces travaux, l'étude s'est concentrée sur la première liste (List One) de TICs qui était constituée d'un ensemble plus restreint de 40 tripodes Thème-Question-Capacité dont on pense qu'ils peuvent bénéficier d'une amélioration de leur niveau de capacité, et qu'ils sont importants pour les opérations futures de l'OTAN, mais ne sont pas actuellement dans le champ des recherches actives menées par la plupart des nations de l'OTAN. Ceci a donné naissance à la troisième réalisation importante de l'étude : la série d'aires de convergences technologiques de Liste Une. A partir de différents travaux de recherches, l'étude JO 2030 a compilé une liste de 247 aires de convergences technologiques. A première vue, cette liste des aires de convergences technologiques, désigne très largement la nécessité d'étudier ou de rechercher des avancées dans les domaines suivants :

- Nombreux domaines de recherche en sciences sociales ;
- Le développement algorithmique ;
- L'exploitation des avancées commerciales dans un certain nombre de technologies ; et
- La compréhension des forces et des limites de la connaissance humaine.

Une seconde analyse des aires de convergences technologiques a conduit à leur corrélation avec un ou plusieurs champs scientifiques, les cinq premiers de ces champs associés étant :

- Les sciences informatiques ;
- L'engineering ;
- Les sciences des systèmes ;
- La gestion ; et
- Les sciences formelles.

Cette liste des champs scientifiques associés représente la meilleure indication sur les domaines d'investissement de recherche, qui en retour peut révéler les solutions possibles, concernant les capacités les plus innovantes qui sont proposées aux nations de l'OTAN dans les années à venir, telles qu'elles ont été identifiées par JO 2030. Dans ce contexte, il est important de comprendre que les capacités les plus innovantes sont les capacités qui n'avaient pas été considérées comme étant des problèmes à résoudre ; elles n'étaient pas supposées être d'un quelconque intérêt pour la recherche active de la part de la plupart des nations de l'OTAN ; et dans la plupart des cas, ce sont des problèmes qui pourraient ne jamais trouver de solution correcte ou acceptable. De la même façon, il devrait être clairement admis que cette liste des principaux champs scientifiques n'implique pas que l'on hiérarchise ces domaines de recherche par rapport aux autres travaux en cours. C'est un sujet qui fera l'objet de travaux ultérieurs.

JO 2030 STUDY OVERVIEW

Long-Term Scientific Studies (LTSSs) have been initiated under the auspices of the predecessors of the NATO Research and Technology Organisation in 10 – 15 year cycles – the last such effort included LTSSs on land, air and maritime operations and was initiated in the mid 1990s. Given that the missions of the Alliance and the attendant global security environment have changed significantly since that time, in 2006, the Systems Analysis and Studies Panel of the NATO Research and Technology Organisation approved the conduct of a new LTSS, SAS-066, on Joint Operations in the year 2030 otherwise known as the Joint Operations 2030 Study.

At its outset, the objectives of the Joint Operations 2030 Study were to:

- Consider the impact that potential future global security environments could have on joint operations across a range of representative operations;
- Determine the types of capabilities that may be needed in this future environment; and
- Consider how applied technologies might have a potential impact upon future capabilities and identify system concepts that could either close capability gaps or significantly enhance capabilities.

Over the course of its three year mandate, the study worked its way through a number of phases and attracted intermittent participation from close to half the NATO Nations and steady participation from 8 NATO Nations and Agencies. Over the course of the study it produced three main outputs:

1) An explorative Thematic Analysis approach for conducting the study;
2) The JO 2030 Capability Set; and
3) A set of List One Technology Focus Areas (TFAs) and associated Fields of Science that merit further consideration for future research and technology investment.

The first major output of the study, the Thematic Analysis approach, employed a series of creative spirals to develop and agree to a set of 18 Joint Operations 2030 Themes. These Themes did not define the future, nor were they comprehensive in their scope, but rather defined a thought space that was used to examine future capability requirements. They were meant to be thought provoking and to be clearly separate from well known and studied trends that many experts have already agreed will have an impact on future operations. In summary the Thematic Analysis approach was a deliberate effort not to validate the well known problems of tomorrow but rather to raise the level of discussion concerning the not so well known challenges that may develop or evolve with time.

The second major outcome of the study, the JO 2030 Capability Set, was built up from the 18 Themes that were generated in the earlier phases of the study, and that were elaborated into 60 Issues and associated with 114 Capabilities the end result of which is a set of 355 Theme-Issue-Capability triplets that constitute the JO 2030 Capability Set. This set of capabilities incorporated the 38 Long-Term Capability Requirements from Allied Command Transformation's Long-Term Requirement Study and as a whole contains a range of traditional, war-fighting capabilities through to some challenging or edge capabilities which would not normally be found in current day Capability Based Planning capability sets.

Due to limits on the resources of the Study Group, the JO 2030 Capability Set was prioritized into three sub-sets or lists. In an attempt to provide the best return for effort the final phases of the study focused on the List One[1] Set of Theme-Issue-Capabilities (TICs) which were a smaller set of 40 Theme-Issue-Capability triplets

[1] During Phase III of the Study, this list, the List One TICs, was originally referred to as the A-List TICs. Initially, there were a number of Lists, A through D, and there was some overlap and confusion about which list was what. To clarify and simplify this issue, the results of the Phase III JO 2030 Capability Set prioritization effort, which were originally called A, C or D List TICs, have been renamed as List One, Two and Three TICs respectively in the Final Report.

that the study considered would benefit from an improvement in level of capability, are important to future NATO operations, but are not currently an area of active research by most NATO Nations. This resulted in the third major output of the study – the set of List One Technology Focus Areas. Working with a variety of research efforts, the JO 2030 Study compiled a list of 247 Technology Focus Areas. This list of Technology Focus Areas, at first look, point broadly towards the need to investigate or seek advancement in:

- Many areas of social science research;
- Algorithmic development;
- Exploiting ongoing commercial advances across a number of technologies; and
- Understanding the strengths and limits of human cognition.

A second level analysis of the Technology Focus Areas resulted in an effort to associate them with one or more Fields of Science, the most frequently associated Fields of Science being:

- Computer sciences;
- Engineering;
- Systems science;
- Management; and
- Formal sciences.

The following table is a list of the Top Ten Fields of Science as associated with the List One Set of Technology Focus Areas.

Table O-1: Table of the Top Ten Fields of Science that were Associated with List One TFAs.

Field of Science	Number of List One TFAs Linked to a Field of Science
Computer sciences	108
Engineering	65
Systems science	64
Management	49
Formal sciences	48
Military science	44
Cognitive sciences	41
Anthropology	36
Social sciences	29
Psychology	28

This list of Top Ten Fields of Science, constitute the best indications of areas of research investment that, in turn, may advance possible solutions to the most challenging capabilities that lay ahead for the NATO

Nations in the coming years, as identified by the JO 2030 Study. In this context it is important to understand what the JO 2030 Study defined as the most challenging capabilities. These were capabilities that were seen as challenging because: they were not well understood as problems that needed addressing; they were not thought to be part of an active research interest from many of the NATO Nations; and, they, in many cases, maybe problems that will never have a correct or acceptable resolution point. As well, it should be clearly understood, that this list of Top Ten Fields of Science doesn't imply any inherent prioritization of these areas of research in comparison to other already ongoing efforts. In the interests of completing the study and given the limited resources available to the study, this was a consideration that was left to a future effort.

Chapter 1 – INTRODUCTION

1.1 SAS-066 JO 2030 BACKGROUND

Three major Long-Term Scientific Studies (LTSSs) were initiated in the 1990s under the auspices of the predecessors of the NATO Research and Technology Organisation. These studies addressed the potential for emerging technology to have an impact on Land, Air and Maritime operations, and recommended technical solutions to shortfalls in capability predicted to occur in the 2015 to 2020 time period. The results influenced planning in NATO Strategic Commands and research and technology activities in NATO bodies and Nations (e.g., Long-Term Capability Requirements and Programme of Work of the Main Armament Groups).

Since the completion of these service-specific LTSSs, the missions of the Alliance and the attendant global security environment have changed significantly, and while many of the previous findings may still be applicable, a range of new operational factors and planning scenarios have appeared. Therefore, in 2006, the Systems Analysis and Studies (SAS) Panel of the NATO Research and Technology Organisation approved the conduct of a new LTSS, SAS-066, on Joint Operations in the year 2030 (JO 2030).

1.2 STUDY OBJECTIVES

At its outset, the objectives of the Joint Operations 2030 Study were to:

- Consider the impact that potential future global security environments could have on joint operations across a range of representative operations;
- Determine the types of capabilities that may be needed in this future environment; and
- Consider how applied technologies might have a potential impact upon future capabilities and identify system concepts that could either close capability gaps or significantly enhance capabilities.

As the study progressed, these broad objectives became focussed on trying to identify research efforts and technologies that could have the potential to impact a set of future capabilities that were identified as both emerging or enduring and necessary for successful NATO Joint Operations.

1.3 STUDY PARTICIPANTS AND AUTHORSHIP

This study attracted representation from close to half of the NATO member Nations. By design it had a Study Group of 10 – 25 participants at any given meeting and a smaller Core Study Team that had agreed to contribute greater effort between meetings. In terms of authorship of the Final Report, it is the product of individual and collective contributions from all members of the Study Group. Details of the Nations and the participants in the study can be found in Annex A.

1.4 AIM OF THE FINAL REPORT

The aim of the Final Report is to provide an overview of the entire study and to present its major findings. The following chapters outline the methodology and report on major accomplishments achieved during the study including the Thematic Analytical Approach, the JO 2030 Capability Set and the Technology Focus Areas that resulted from the solution solicitation effort conducted in the final phases of the study.

1.5 OUTLINE OF THE FINAL REPORT

It is intended that this Final Report will be a complete record of the study. As such, it includes a chapter that summarises the context and working assumptions that the Study Group agreed to employ over the course of the study; a section on the study's methodology; a section that reports on the Themes that were generated by the Thematic Analysis; a section that describes and reports on the JO 2030 Capability Set; a section that presents the efforts to identify Technology Focus Areas; a section on the final results of the study; and finally, a discussion of the results, recommendations and conclusions of the study.

Chapter 2 – STUDY FACTORS, CONSIDERATIONS AND ASSUMPTIONS

Over the course of the study and especially during its early phases, the Study Group actively discussed a number of factors and agreed to a number of assumptions that informed the study's methodology and research efforts. While many of these assumptions and precepts were well discussed in advance or during the study, a few came to light towards the end, with the clarity that only comes from hindsight. In no particular order, but as context that underpins the study's efforts and results, these assumptions are:

- 2030 is a reference year – this was meant to be far enough into the future so that many things that are thought to be near to realisation would be realised allowing the study to think beyond that notional reality. It was meant to push beyond the current short and medium term planning horizons of NATO and the Nations. It was also meant to give the Study Group greater freedom to explore areas that, whether for reasons of policy, organizational imperatives or politics, are currently considered to be intractable or unchangeable realities. Given that technological advances often progress at different and varying rates, the Study Group attempted to think of this less as a 'point' in time and more as a period of time 15 – 25 years into the future.
- Disruptive Technologies (SAS-062) – A second reason that the JO 2030 Study choose to try and look for solutions in the early stages of investigation and development was to establish a point of differentiation with the SAS-062 Disruptive Technologies Study which was in progress when the JO 2030 Study began [1]. SAS-062 was studying the operational utility of a number of Ideas of Systems that were generally at a Technical Readiness Level (TRL) of between 4 – 7, and as such, might be fielded in the next 2 – 10 years. As both were SAS studies they worked closely to avoid overlap and duplication which was achieved, in the case of JO 2030, by focussing on a different future time frame (2030) and looking deliberately for solutions in the early stages of investigation and development. Figure 2-1 below offers a visualization of this separation.

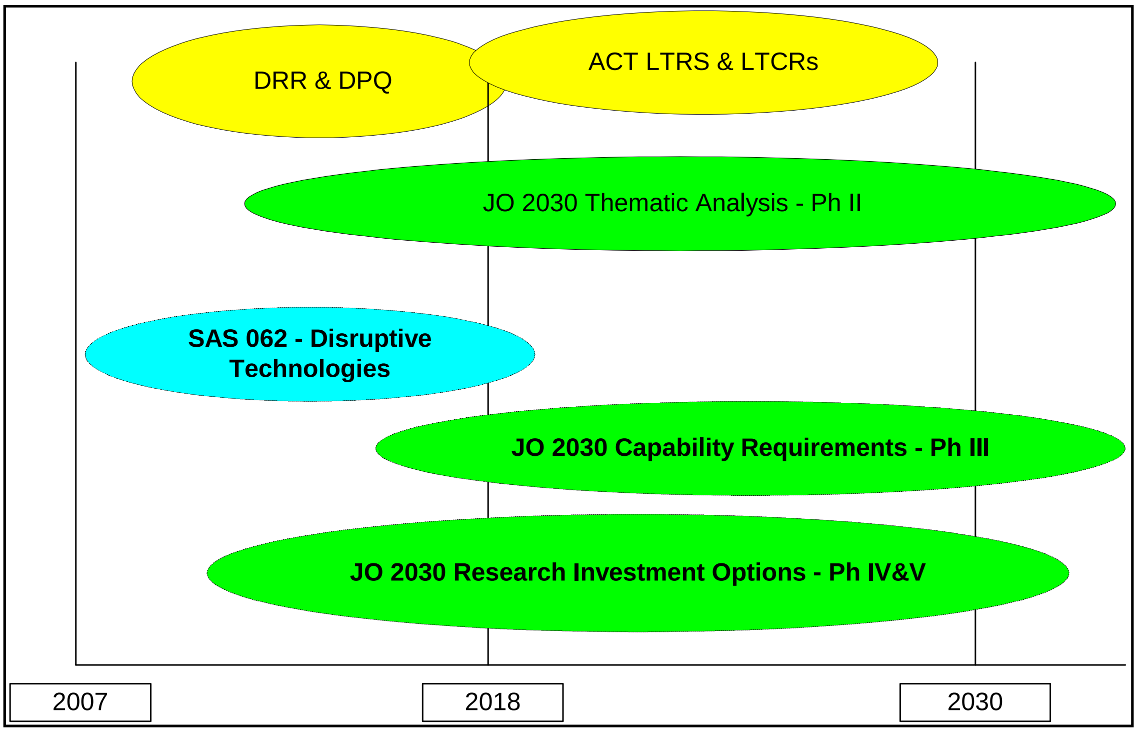

Figure 2-1: JO 2030 Relation to SAS-062 and NATO Defence Requirements Review (DRR) and LTRS.

- As the Alliance's first 'joint' Long-Term Scientific Study the Study Group agreed early on to go even beyond this 'joint' focus to also include inter-agency and even truly 'comprehensive' capabilities – albeit always with a specific focus on the defence aspects of such more comprehensive capabilities.
- Technology Readiness Levels – Technology Readiness Levels (TRLs) refer to a scale of 1 – 9 that tracks the level of maturation of a given technology from basic research, TRL 1, through to a mature and fielded technology, TRL 9 [2]. In this context JO 2030 assumed that it was searching for ideas and solutions that were generally at the lower TRL levels.
- Objective or Goal Oriented – The Study Group sought to address current and future challenges for which there is no ready solution; and to be unconstrained by the present which allowed the Group to consider how things might be. This was less of an effort of projecting today's challenges and trends on to what tomorrow would be like and more of an attempt to overcome these challenges by asking what could one do.
- Future Security Environment and Trend Analysis – The Study Group agreed that it would be informed by, but not constrained to, the many well-known trends and foresight studies of the future. These include such things as trends and forecast advances in computer processing, global warming, nanotechnology, robotics, shifting demographics, and bio-technology, to name but a few.
- The Use of Scenarios – The Study Group accepted that forecasting future changes and conditions is very difficult and was concerned that the adoption of any one scenario or set of scenarios too quickly traps people in preconceptions and undisclosed assumptions. The Study Group also recognised that developing consensus on any one or a set of scenarios would be difficult. Finally, it agreed to leave as much room as possible for free and open minded thinking, and for these reasons it decided not to use scenario analysis for the purposes of the JO 2030 Study.
- NATO in 2030 – While the Study Group did try to remain open to many possibilities it did agree that, given that JO 2030 was a NATO Research and Technology Organization directed study and that it was sponsored by the NATO Conference of National Armaments Directors, that, per force, NATO itself would remain a viable alliance in 2030.
- NATO has a Kinetic Competitive Advantage – which is to say that NATO has and is expected to retain a well-demonstrated ability to win on and even dominate a traditional military battlefield. On the other hand, many of the challenges in future joint operations will be at the edges of this battlefield; at the pre and post conflict points of the battlefield; be of a non-kinetic nature; and will characteristically be concerned with human problems that will need human solutions.
- NATO Policy and Doctrine – The JO 2030 Study agreed to be informed by NATO's current policy and doctrine, but not to be constrained by it. In other words, it was assumed that if it needed or wanted to, NATO could or would change. This ranged from continued change in its membership; to organizational changes in how the Alliance is structured, managed and administered; and to various doctrinal debates.
- Classification – It was agreed to conduct the bulk of this study at the unclassified level. This would keep open as many doors as possible and allow easier access to the study by a wider range of participants and contributors. Though some topics could have led to the need to consider a classified segment or section, the Study Group never came to a point where it felt it needed to work at a classified level.

Chapter 3 – STUDY METHODOLOGY

3.1 OVERVIEW OF THE STUDY METHODOLOGY

The Joint Operations 2030 Study was initially scoped to be conducted in five phases. Broadly, the study set out to understand and agree to the definitions and assumptions that would define the study, embark on an effort to define the needs or capability requirements that a NATO Joint Operation might call upon in the 2030 time frame, and then search for research and technology ideas or investment opportunities that, if supported, offered some promise of significant improvement to the delivery of that capability in a future operation. As initially articulated in the study's Terms of Reference (Annex B), the five phases of the study were as follows:

- Phase I: Establish the strategic environment, scenarios, and concept of operations for NATO in the year 2030;
- Phase II: Determine the baseline capabilities for NATO in the year 2015;
- Phase III: Assess capabilities that will be pertinent to NATO in the 2030 time frame and undertake a capability gap analysis using the 2015 Baseline Capabilities;
- Phase IV: Assess the potential for technological developments to have an impact on capabilities, force structures and, operational concepts; and
- Phase V: Staff a working paper through a multi-national Workshop and generate a final report making recommendations.

While the Terms of Reference laid out an initial approach to this study it is important to appreciate that Long-Term Scientific Studies occur infrequently and the last such set of studies took place in the period of the mid to late 1990s [3 – 5]. As well, this was the first such study that was being attempted at a joint level vice previous efforts that had followed a service specific or environmental focus, and a study that decided early on to go beyond what it is currently feasible within a NATO alliance context by also embracing inter-agency and even truly comprehensive capability aspects. Furthermore, as the study progressed, on a number of occasions it became apparent that the scope and ambitions of the study greatly exceeded the efforts and resources the Study Group was able to apply to the study. These factors all, in turn and to various degrees, contributed to a number of adjustments to the Study's methodology over the course of the study such that the five phases evolved as briefly described in each of the following sections and as depicted in the following schematic, Figure 3-1.

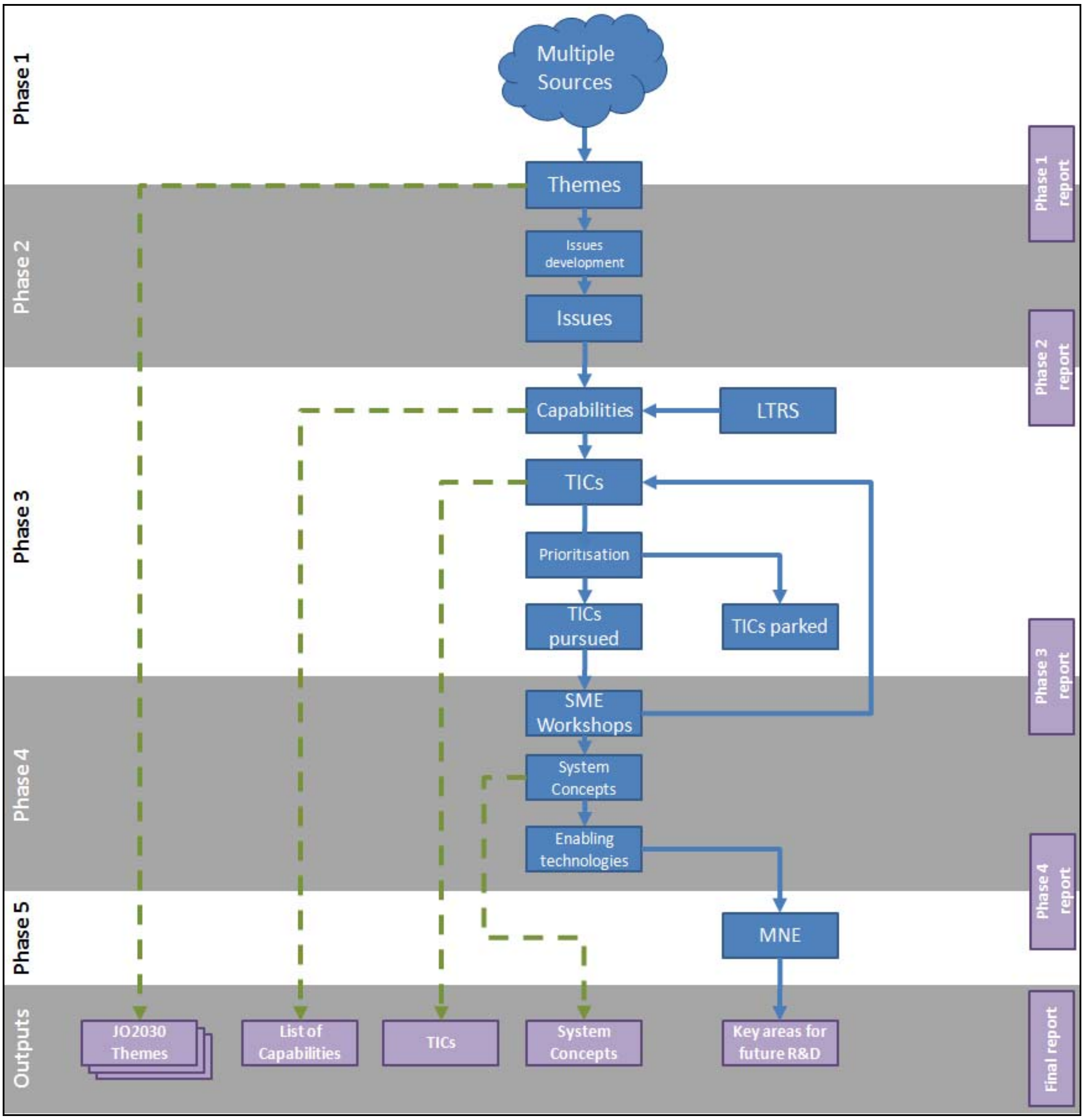

Figure 3-1: JO 2030 Study Flow Diagram with Phases and Activities.

3.1.1 Phase I: Strategic Environment, Scenarios and CONOPS

This phase allowed for the establishment of the fundamental parameters, guidelines and assumptions for the study [6]. In this phase, a host of perspectives on global future analysis, trends analysis, the future security environment, the role of scenarios and future worlds issues, including Allied Command Transformations (ACTs) Long-Term Requirements Study (LTRS) (and later in the process) ACT's Multiple Futures Project efforts were discussed and adopted as scene setting contextual material in order to postulate a future world of NATO Operations some 20 plus years hence. This provided an agreed political-military context that underpinned future work on capability requirements and toward the end of this phase a list of Themes was generated that would allow the Study Group to explore a number of not yet well-defined Issues that lay at the edges of NATO military operations. These Themes were not intended to define completely the future nor be truly comprehensive in their scope. They were meant to be complimentary to other concurrent efforts, specifically ACT's LTRS. The Study Group saw this Thematic Analysis as being inspired by the strategic planning theories of Mintzberg and Waters [7], Figure 3-2, who suggested that any 'realised' strategy was actually the combination of an 'intended' strategy (i.e., the ACT LTRS) and an 'emergent' strategy (represented by the 18 Themes).

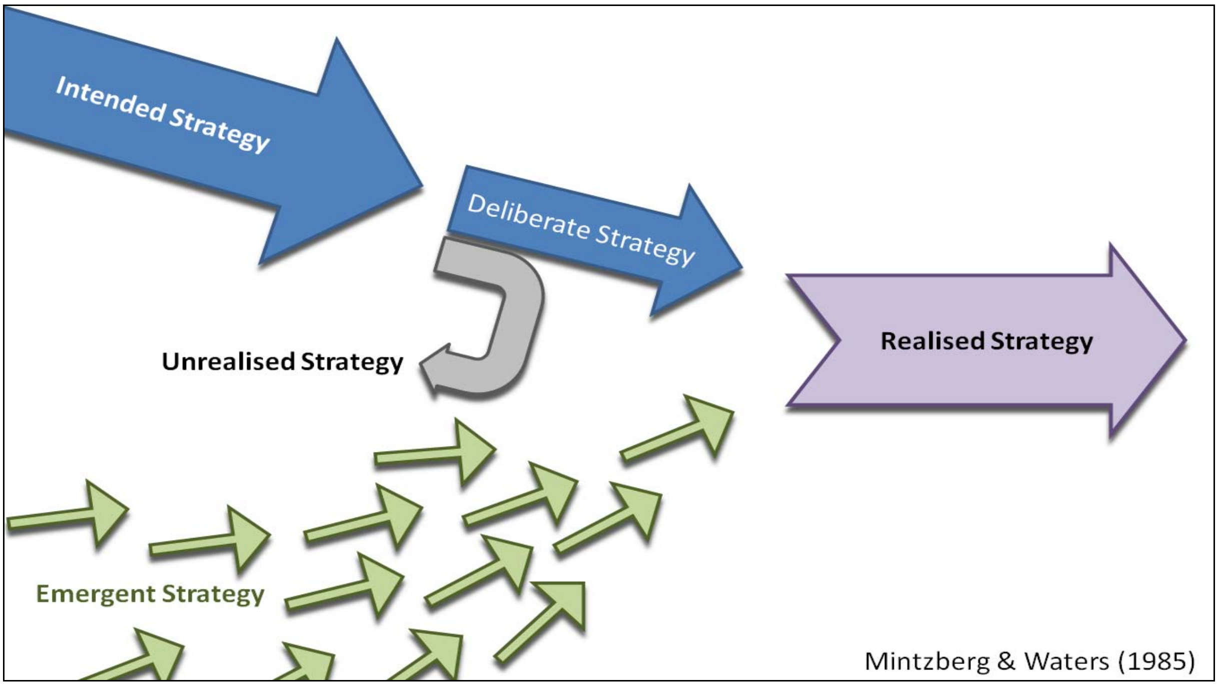

Figure 3-2: Mintzberg and Waters Realised Strategy [7].

3.1.2 Phase II: Thematic Analysis

In Phase II, the Study Team further developed, described and settled upon 18 Themes that had been initially articulated in the later stages of Phase I [8]. A Theme was considered to be a description of developments that could lead to or provoke manifest changes in the 'why' (role and embedding), 'what' (missions and tasks) and 'how' (structures, processes, and concepts of operation) of future NATO military operations and organisations. The JO 2030 Study viewed these Themes as topics that:

- Stemmed from fundamental, longer-term developments in the environment in which NATO will exist and operate;
- Could drive future capability requirements not only in terms of 'hardware', but for any of the Doctrine, Organisation, Training, Material, Leadership and education, Personnel, Facilities, and Interoperability (DOTMLPFI) elements; and
- Might invoke or undergo profound change, in terms of DOTMLPFI elements or 'mind set' (e.g., political, social, or moral contexts).

The Thematic Analysis allowed the Study Group to consider many issues and problems that were perceived to lay at the edges of or to be beyond the traditional interpretation of the battlespace of a NATO Joint Operation and, therefore, would not be covered adequately within existing defence and security planning processes. In fact one important selection criterion for the Joint Operations 2030 Themes was their originality when compared to the scope of existing defence planning processes. The 18 Themes were further elaborated through description of associated Issues and Capabilities, and ultimately evolved to be a set of Theme-Issues-Capabilities, referred to within the study as TICs.

3.1.3 Phase III: Defining and Prioritizing the Joint Operations 2030 Capability Set

During Phase III, this growing set of TICs were then combined and merged with Allied Command Transformation's Long-Term Capability Requirements the end result of which is a JO 2030 Capability Set of 354 different TICs, Figure 3-3.

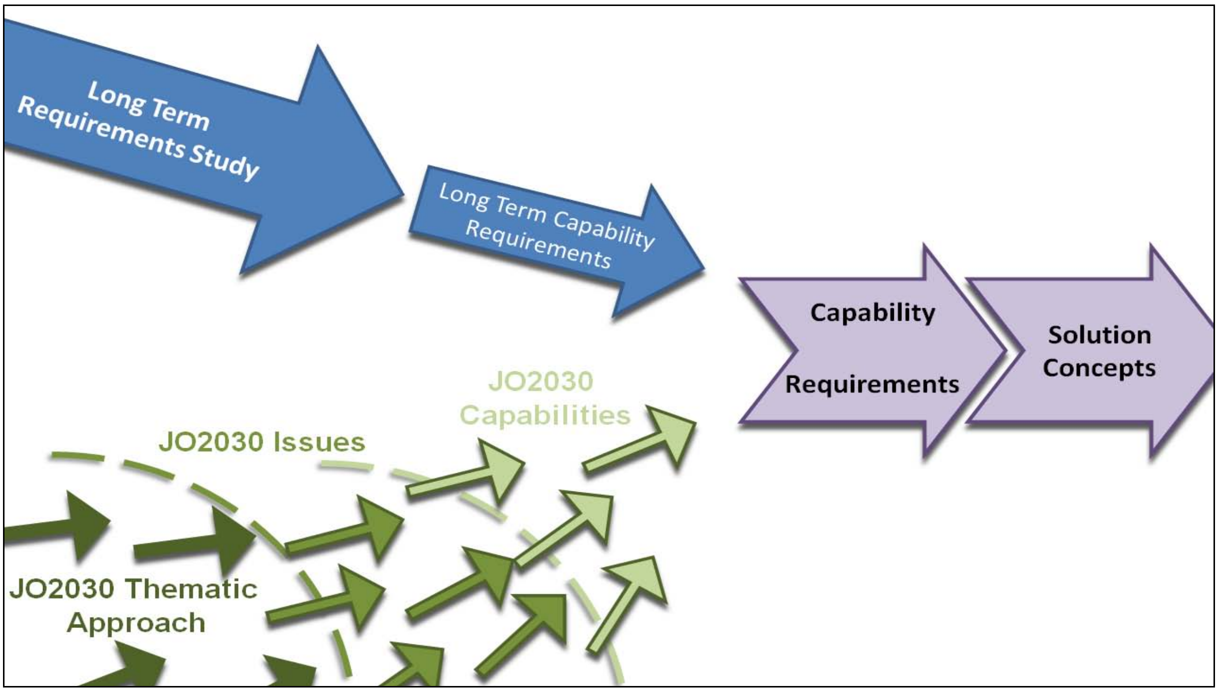

Figure 3-3: Joint Operations 2030 Thematic Approach.

The JO 2030 Capability Set covered a range of traditional and non-traditional military capabilities in addition to requirements that are emerging in the face of a rapidly shifting future security environment. Some of these capabilities might be said to exist at the edges or outside of the current scope of NATO operations [9]. They can also be said to span the domains of doctrine, organisation, training, materiel, personnel, leadership, facilities and interoperability for a future NATO Joint Operation. At this point in the study, given the limited resources of the Study Group and the large size of the Capability Set, it was decided to prioritize this set of 354 TICs. This prioritisation resulted in the following three unique classifications of TICs:

- List One TICs[1] – are important to future NATO operations but are assessed as not being currently an area of active defence science orientated research;
- List Two TICs – are important to future NATO operations but are currently supported by an active research effort by more than one or two NATO Nations; and
- List Three TICs – are of lower importance to future NATO operations.

3.1.4 Phase IV: Searching for Solutions for the List One Capabilities

Due to the limited resources available from the participating Nations, Phase IV focussed on the 40 List One TICs. The effort of searching for solutions involved a combination of: RTO Outreach efforts;

[1] During Phase III of the Study, this list, the List One TICs, was originally referred to as the A-List TICs. Initially, there were a number of Lists, A through D, and there was some overlap and confusion about which list was what. To clarify and simplify this issue, the results of the Phase III JO 2030 Capability Set prioritization effort, which were originally called A, C or D List TICs, have been renamed as List One, Two and Three TICs respectively in the Final Report.

the conduct of Solution Solicitation Sessions (SSS); and literature searches. The RTO Outreach efforts involved connecting with the expertise that was resident in the seven other RTO Panels. The SSSs were organised as a series of small focus group meetings that were held with a variety of subject matter experts. In all, 25 of these sessions were held in seven different Nations with a variety of experts drawn from military officers, defence planners, defence scientists, academic institutions, industry scientists and engineers, policy experts, strategic analysts, and legal experts. The input from these sessions where combined with data gleaned from a number of national efforts to conduct literature and key word searches on various topics. As Phase IV progressed it became clear just how challenging it is to think beyond the present, beyond the known, or beyond the current scientific disciplines that reside in the defence science communities of the participating Nations. This lead to the realization that efforts to find solutions to these challenging capability needs proved to be more difficult than had been anticipated. The results that were obtained were less a set of well-defined solutions and more a set of possible areas of further explorations which came to be known as Technology Focus Areas.

3.1.5 Phase V: Multi-National Exercise and Final Report

The last phase of the study involved the conduct of a Multi-National Exercise (MNE) and the completion of the Final Report. The Multi-National Exercise took the form of a 2½ day Symposium held at the Assembly of the Western European Union in Paris during the period 8 – 10 September 2009. In attendance were a total of 41 participants from 11 different NATO Nations and 4 Partners-for-Peace Nations. This included 14 members of the JO 2030 Study Group and representation from the NATO Research and Technology Agency (RTA).

The MNE addressed significant areas of interest in the JO 2030 Team's analysis of important technology areas to close projected capability gaps in the 2030 time frame. Overall, the MNE allowed for a mix of defence scientists, military officers, defence planners, industrial representatives, and academics to provide a synergistic and integrative review of the JO 2030 Study efforts.

The Phase IV efforts and the MNE generated a set of over 247 Technology Focus Areas (TFAs) associated with the 25 Capabilities drawn from the 40 List One TICs. In the final effort to extract some meaning and focus from this list of Technology Focus Areas they each were associated with one or more Fields of Science all of which is reported upon later in this study's Final Report.

3.2 JO 2030 STUDY OUTPUTS

As can be surmised from the five Phases of the study as described above, the JO 2030 Study produced three major outputs, namely:

- A Thematic Analysis methodology which generated a set of 18 JO 2030 Themes;
- A JO 2030 Capability Set of 354 Theme-Issue-Capabilities combinations including three prioritised lists of sub-sets of the JO 2030 TICs; and
- A list of Technology Focus Areas that could address the List One Capabilities from the JO 2030 Capability Set.

Each of these major outputs is the subject of the following sections of this report.

Chapter 4 – RESULTS OF THE THEMATIC ANALYSIS

4.1 PHASE I AND II – IDENTIFICATION OF THEMES

In Phase I and II fundamental, longer-term developments in the environment in which NATO might operate were considered. These developments could come from breakthroughs or shocks in the geopolitical security environment, in the institutional context, in technology development or in underlying social, economical, moral, or legal structures. This stage drew upon a wide range of sources, including ACT's Long-Term Requirements Study, various national internal strategic assessments, and other related future security analysis. These efforts and considerations led the JO 2030 Study to define a Theme as a description of developments that could lead to or provoke manifest changes in the 'why' (role and embedding), 'what' (missions and tasks) and 'how' (structures, processes, and concepts of operation) of future NATO military operations and organisations.

The desire of the Study Group to ensure that JO 2030 complemented other studies of the long-term future meant placing particular emphasis on possible developments and consequences that were not typically covered by more traditional extrapolation-based long-term defence planning methods. The second principle was that in an era of significant uncertainty, striving for 'completeness' was impractical. Not only would analysing a statistically robust number of possible futures outstrip the resources available to the study, but as a matter of principle, one would not be able to postulate a set of scenarios that represented, with any confidence, all possible relevant future environments and potential military endeavours. This principle meant that Theme generation was creative, rather than a well-established or rigorous derivation and selection method.

Employing a series of creative spirals and iterations the JO 2030 Study agreed upon a set of 18 Themes. These Themes do not define the future, are not intended to be comprehensive in their scope or coverage. They were meant to be provocative and to be distinct from well-known and studied trends that many experts have clearly agreed will have a impact on future operations such as nanotechnology, climate change, or robotics to name but a few, and as illustrated in Figure 4-1. In summary the Thematic Analysis was a deliberate effort to not simply validate the well-known problems of tomorrow but rather to raise the level of discussion of the not so well-known challenges that may develop or evolve with time.

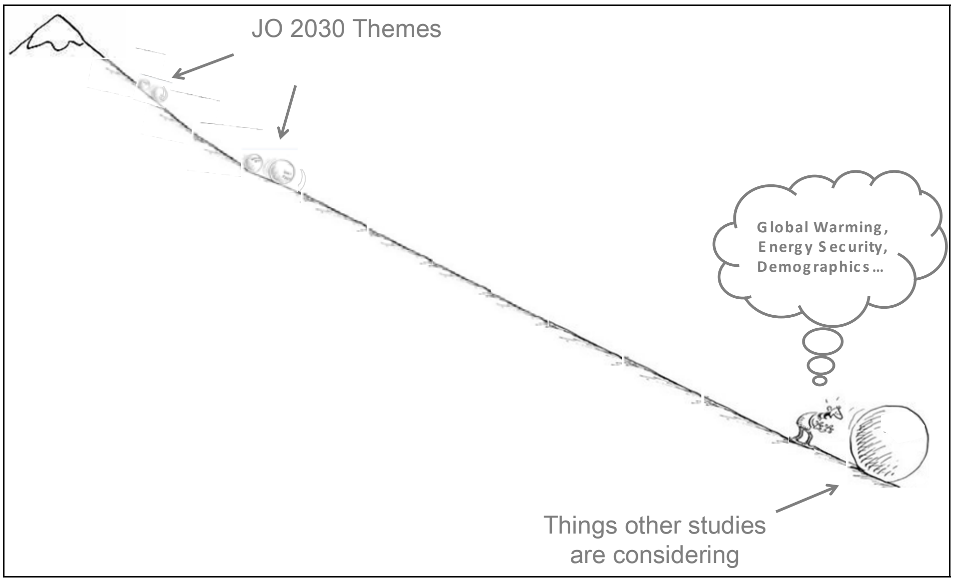

Figure 4-1: Metaphorical Depiction of JO 2030 Themes.

The titles and a brief description of the 18 agreed to JO 2030 Themes are as follows.

4.1.1 Theme 1 – Blurred Distinction between Peace and Conflict

The distinction between peace and conflict will become more blurred over the next decades as forces are used to accomplish traditional and non-traditional military missions in areas where a sustained threat will be present. This will be brought about by the globalization of the threat from terrorists, extreme fundamentalists, trans-national criminals and weapons proliferation. There will be a shift from the sequential, phased, contiguous operations of the past to more continuous, simultaneous, parallel and distributed operations bringing military forces in contact with civilians, NGOs and indigenous security forces as well as a variety of opposing forces with diverse motives for conducting violent and non-violent actions.

4.1.2 Theme 2 – Standing Arrangements

Increasingly, in order to achieve its political and military objectives, the Alliance will operate within a comprehensive approach that will include a host of non-military supporting/supported organizations. The complementary capabilities of these partners will increase the overall capability of the Alliance to achieve its goals and, thus, must be included in the early planning and execution phases of operations to ensure their coherent application. These organizations will include Non-Governmental Organisations, international and regional organisations, and private contractors, which are increasingly being used in outsourced non-core military capabilities. In order to successfully coordinate lines of development and to integrate these organizations into operations, it will be necessary to consider them within the operational planning process and to develop standing arrangements.

4.1.3 Theme 3 – Planning Under Deep Uncertainty

In the past, where conditions were relatively stable, Alliance defence and operational planning processes were deliberate and reflected ‘strategy as design’. The fluidity and pace of change within the emerging globalised environment will increasingly demand that planning for Alliance operations will be done under conditions of deep uncertainty. Deep uncertainty is present when decision-makers do not know or cannot agree on the current system model of how things fit together, prior probabilities, timing and cost. This will require a new suite of methods and analytical tools to support decision-makers in a ‘strategy as process’ manner to develop capabilities that are flexible, adaptable and robust.

4.1.4 Theme 4 – Different Paradigms in Decision-Making

The interconnected strategic environment of the 21st century has given rise to increased uncertainty and complexity. These emerging threads have been grasped by increasingly adaptive opponents. For the Alliance to be successful in the coming decades, it will have to undertake politically and militarily complex missions requiring a comprehensive approach. The interaction of changing circumstances in the strategic and operational environments will require different paradigms for decision-making. The complexity of future Alliance operations implies both quantitative and qualitative changes in the information and analytical support needed to make good and timely decisions. This could mean a move from the current paradigm of ‘command and control’ to one of ‘focus and convergence’.

4.1.5 Theme 5 – Evolving Relationships between Man, Robotics and Machine Intelligence

The exponential increase in computing power over the coming decades will lead to advances in artificial intelligence and the increasing use of robotics in military operations. The removal of the ‘man from the loop’ has beneficial effects, but also leads to questions on how to incorporate these advances into military operations. In operations where concerns over fratricide, defective targeting and collateral damage may override effectiveness, reluctance to deploy autonomous weapons system may persist. These advances demand changes in other aspects of military planning and execution brought about by the increasing speed of action available to autonomous systems.

4.1.6 Theme 6 – Staying Power

It is possible in the coming decades that Alliance military forces will be engaged on a more or less continuous basis in operations requiring significant numbers of the troops and weapons systems. To successfully undertake such operations over time will require 'staying power' from Alliance Nations to remain engaged. There is a perception that Alliance forces currently do not possess sufficient staying power to engage a tenacious, adaptive enemy that seeks to keep Alliance forces engaged for a long period. Staying power must be developed at several conceptual levels:

- Political – political priorities and messages must be aligned to keep forces engaged;
- Operational – clever campaign design, use of technology, avoidance of too ambitious operations and increased forces; and
- Tactical – operations are typically undertaken by small units demanding improved equipment, protection and tactics.

4.1.7 Theme 7 – Small Team Operations

In the future, military operations will increasingly be the domain of small units and teams. This will include variants of small fighting units and multi-disciplinary teams designed to address specific multi-faceted problems where security only forms part of the puzzle. These teams must generally work autonomous, independent missions for considerable periods of time. These teams must be able to shape the 'command intent' to develop solutions based on local conditions. They must be to 'sense and respond' independent of the larger force and adapt accordingly. This will drive modularity and networked requirements.

4.1.8 Theme 8 – Strategic Compression

Strategic compression can be defined as the forming of unexpected casual relationships and breaking of expected causal relationships among the tactical, operational and strategic levels of conflict in the political, information, military and economic domains. This is a combination of the 'strategic Corporal' and the 'tactical Politician'. This is brought about by the interconnectedness of the globalised environment and the pervasiveness of the 24-hour media cycle supported by almost instantaneous information systems and networks allowing more people access to more information. The coalition nature of most future operations will increase the importance of controlling strategic compression to maintain the coherence/ viability of the coalition.

4.1.9 Theme 9 – Dual-Use Technologies

The concept of dual-use technology has most recently been used to describe the use of commercial technology for military purposes. With the bulk of research and development funds being expended on commercial development of technology, it very likely such developments will produce systems that will have a collateral military use. As scientific advances increase exponentially over the coming decades, there will be a requirement to monitor commercial technology for those developments that could give possible adversaries a mechanism to produce weapons systems.

4.1.10 Theme 10 – Non-Military/Non-Violent Threats

The Alliance will face a variety of complex threats in the future. These include non-military threats where the source of the threat are non-conventional military forces and non-violent threats wherein, though it may be an enabler or an intended consequence of the action, violence is not an inherent element. These threats could come about through deliberate action, accidental occurrences or natural disasters. The cause and effect of these events is not limited by borders and are characterized by difficulty in prediction, detecting, localizing and typically involve little or no warning. They require trans-national coordination and inter-agency cooperation to resolve. Examples of these types of threats include:

- Computer network attack;
- Pandemics;
- Mass migration; and
- Natural disasters.

4.1.11 Theme 11 – Regeneration

Most NATO Nations have moved away from large forces toward smaller, more professional and more technologically intense forces as the threat from a peer competitor has receded over the last decades. The focus has moved to fighting short, intense battles against a medium sized force or conducting, what had been termed ‘lesser included’, missions such as counter-insurgency or stabilization/reconstruction. Regeneration refers to the ability of the Alliance to restore operational capabilities that formerly had been in its inventory or to develop a capability that is technically feasible but is not available for immediate use. Regeneration includes recognizing the need for taking action, conceptualizing the capabilities, deriving DOTMLPFI and producing the capability.

4.1.12 Theme 12 – Three Domains of War: Physical, Mental and Moral

Kinetic activity associated with traditional military operations has been joined by actions in the moral and mental (information) domains as equal components of a success campaign plan. The war of ideas, hearts and minds, fourth generation, amongst the people has stressed the relevance of the moral and mental domains. As asymmetric adversaries avoid exposing themselves to the superior conventional force of the Alliance, the importance of actions outside the physical domain become more obvious. Within irregular warfare the importance of the moral domain becomes dominant as the security of the people becomes an overarching goal. In the future, physical actions will be used to enable the achievement of objectives in the mental and moral domains.

4.1.13 Theme 13 – Coalition Operations

In the future, no single instrument of power will be able to solve complex crises. Coalitions will be used extensively to conduct all manner of military operations. Members of the coalition will provide various capabilities to the force while accepting differing levels of risk. Coalition operations will highlight areas such as interoperability and common doctrine. The ability to develop a common strategy within a common legal framework will be crucial to the achievement of coalition objectives. This Theme raises issue of interoperability, role specialization, training and equitable sharing of costs and risks.

4.1.14 Theme 14 – Space is Opening Up

By 2030 the amount of traffic in space will have increased markedly requiring coordination and regulation. The Alliance will remain dominant in this area with capabilities for Intelligence Surveillance and Reconnaissance, navigation and weather observation based in space. The commercial sector of particularly western economies also relies heavily on space communications. The reliance of the Alliance on space could develop into a focus area for possible adversaries that could seek to exploit this potential ‘Achilles Heel’. Space junk and anti-satellite systems are threats to the usage of space during operations. Commercial enterprises have built to allow even small groups to have access to space imagery that could be used for intelligence purposes. Space situational awareness becomes an important component for future Alliance operations.

4.1.15 Theme 15 – Cost Escalation

It will be critically important to have a full understanding of the growing costs of developing and operating military weapons systems. With constant defence budgets in real terms, the increasing unit and operating/ maintenance costs of systems and personnel will bring about reductions in force structures over time. Long-term planners will require knowledge of operating cost escalation and investment cost escalation. The effects of technological progress that improves a product's quality or performance as opposed to those that make the production process more effective are discussed, and it is highlighted that the former more readily affects military systems as Nations attempt to acquire smaller numbers of 'state of the art' systems. Combined with acquisition in the early stages of product development (limiting cost reductions from learning), the inability to allocate research and development across a high number of systems, and the likelihood that these systems are manufactured in high labour cost Nations results in cost escalation.

4.1.16 Theme 16 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the 'whole-of-government' or 'comprehensive' approach; and
- The need to garner public support for ongoing operations.

4.1.17 Theme 17 – The Role of Information and the Media

The media has become instrumental in developing the context for the public audiences that affect the Alliance. The pervasive 24/7 media cycle will continue to create the 'CNN effect' where strong emotional content can engender public reaction which may affect political and military decision-making at all levels of command. There is a symbiotic relationship between the military and the media in that the media requires access and information and the military needs the media to communicate with the public. The increased instantaneous access to information available to the public will be a serious consideration in the future as public perception can drive constraints on both the political and military levels.

4.1.18 Theme 18 – Super-Empowered Individuals

In the coming decades, access to, development, deployment and usage of powerful conventional and unconventional weapons, including Weapons of Mass Destruction (WMDs), will have spread to not only small countries, but will come within the reach of non-state actors such as terrorist networks and trans-national criminals. The exponentially accelerating convergence of nanotechnology, biology, information systems and cognitive sciences – all of which have major dual-use potential – will enable groups as small as single individuals to develop highly dangerous weapons. Lower barriers to access to the required knowledge and technology will enable to low cost – low signature production of weapons with destructive power up to those of WMD. The combined effect of these trends has been termed 'toxic knowledge' or the 'holocide intercept' where individuals could conceivably endanger large parts of society.

In an effort to ascribe further meaning to these 18 Themes, Figure 4-2 is an effort to cluster the 18 Themes into larger thematic clusters, such as:

- Political;
- Economic;
- Environmental;
- Structural;
- Technological;
- Long-term commitment; and
- Focus and coherence.

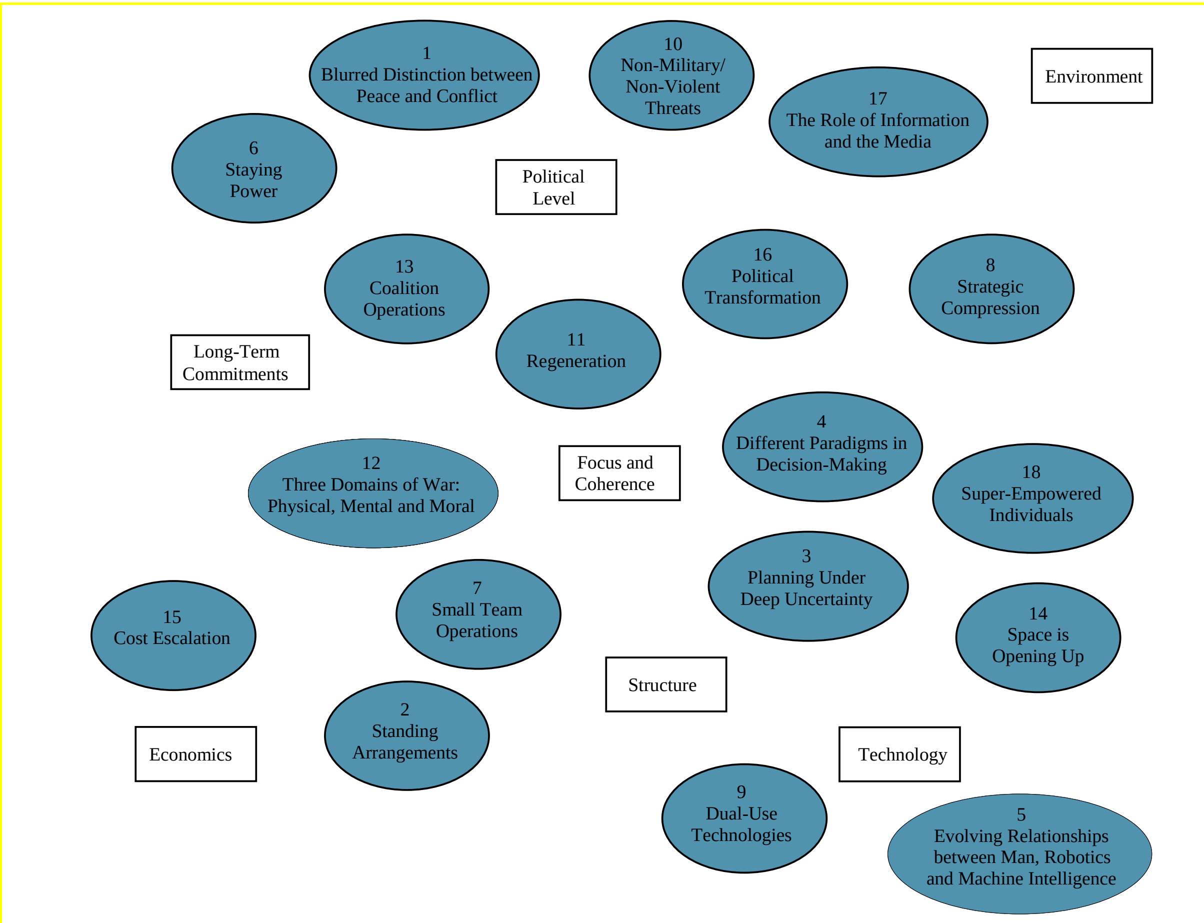

Figure 4-2: Association Diagram Showing the Eighteen JO 2030 Themes.

Chapter 5 – THE JOINT OPERATIONS 2030 CAPABILITY SET

5.1 JOINT OPERATIONS 2030 THEMES TO ISSUES

Over the course of a number of meetings, small groups took each Theme and generated Issues and subsequently associated Capabilities that seemed to follow from the Theme itself. Issues were intended to reflect what the Theme could lead to, not what brought about the Theme itself. The Issues were considered to be an intermediate step towards generating a capability requirement, and in this context Capabilities were seen as a way to address the Theme-Issue at hand.

During the generation of the Issues, similar Issues were often developed under different Themes. This led to an analytical effort across the Themes and Issues. In some instances the analysis resulted in the Issue retaining an association with multiple Themes, in others similar Issues were placed under one Theme. In one case, different Issues were grouped under a new Theme. Furthermore, it was evident that many Issues were related to each other. For instance, a particular issue might generate the context for other issues.

After the analysis, 60 distinct Issues remained. Figure 5-1 shows an example of the Theme-Issue analysis conducted. Elements highlighted in orange were where a decision was made pertaining to an Issue with links to more than one Theme, or in the case of information and media, where a new Theme was developed under which Issues were placed.

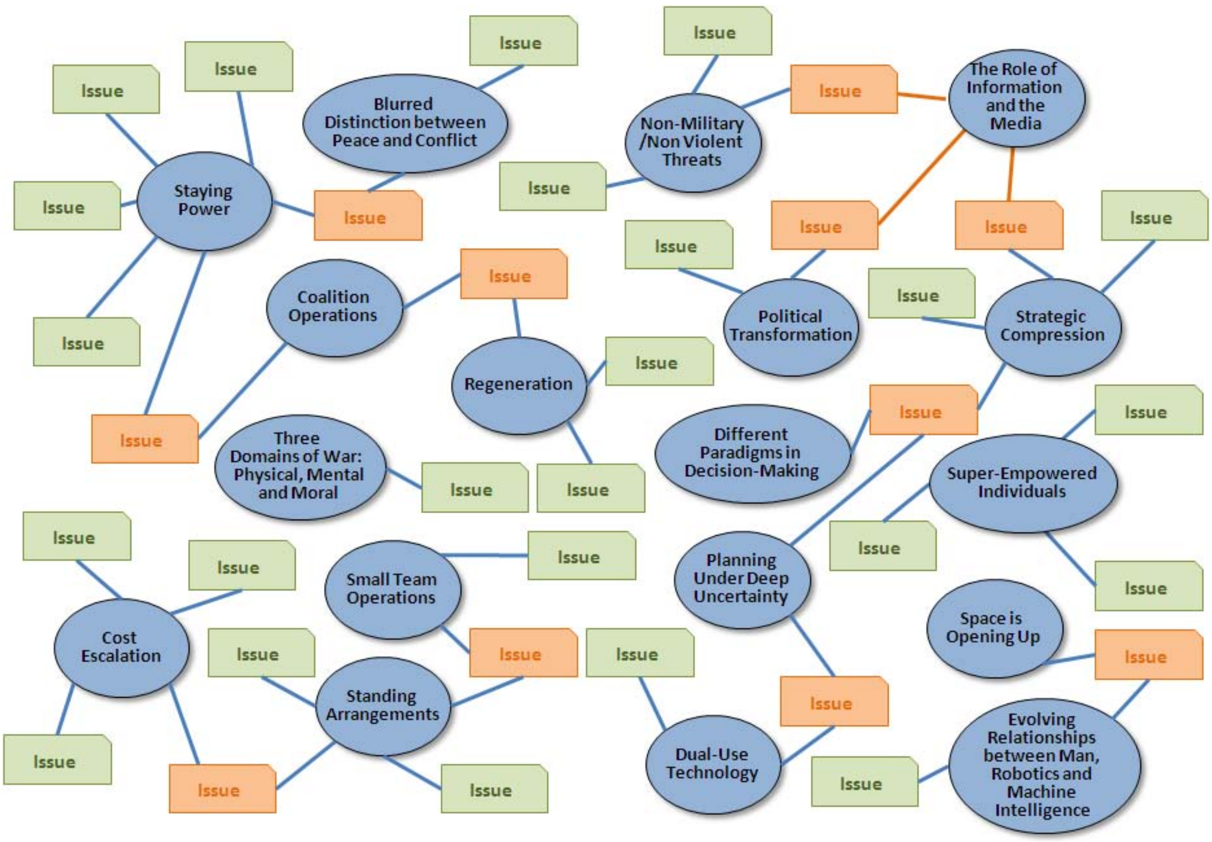

Figure 5-1: Example of the Theme-Issue Analysis.

5.2 JOINT OPERATIONS 2030 THEMES-ISSUES TO CAPABILITIES

Using the Theme-Issue nomenclature, Phase III derived Capabilities for each of the Issue-related problem statements. The Joint Operations 2030 Study Team also incorporated the 38 LTCRs from Allied Command Transformation's Long-Term Requirement Study as a set of potential ready-made requirements. Each LTCR was examined to see if it was suitable for any of the Theme-Issue combinations. Finally, after the LTCR had been explored, the Study Group then developed desirable outcomes for all of the Issues, which in turn led to the identification of the associated Capabilities. In most instances, multiple Capabilities were identified for each Issue.

Across the 60 Issues a total of 355 Theme-Issue-Capability triplets were generated. This forms the JO 2030 Capability Set. The language used to describe the Capabilities was kept generic, which led to the use of the same Capability statement in different Theme-Issue combinations. There are 114 unique Capability statements. Using generic descriptions for the Capabilities allowed the Team to identify common needs across the Theme-Issue-Capability triplets; however, in doing so, it should be noted that only a combination of a Theme, an Issue and a Capability describes accurately the requirement as this context should influence possible solutions.

5.3 PRIORITIZING THE THEME-ISSUE-CAPABILITIES – LISTS ONE, TWO AND THREE

Given what could be achieved with the resources available to the JO 2030 Study Group, this JO 2030 Capability Set of 355 Theme-Issue-Capabilities was too large a number to pursue. Therefore, a prioritization exercise was conducted to identify a sub-set of TICs that the Study Group could focus on. The Study Group identified three criteria that were used to prioritize the JO 2030 Capability Set:

1) Likelihood of a Theme-Issue-Capability being a gap across many NATO Nations in the 2020 – 2030 time frame (low, medium, or high);
2) The potential for a Theme-Issue-Capability to have an impact on NATO operations in the 2020 – 2030 time frame (low, medium, or high); and
3) An assessment as to whether or not research efforts to reduce or address a Theme-Issue-Capability will be undertaken by Nations or industry (unlikely, likely, or very likely).

The Study Group scored all of the TICs against these three criteria and the resulting analysis of the scores led to the TICs being separated into three groupings, Lists One, Two and Three, such that:

- List One TICs scored highly under all three criteria;
- List Two TICs scored medium or highly for two of the criteria; and
- List Three TICs scored low or medium for two or three of the criteria.

Another way of looking at these three groupings is that:

- List One TICs are important to future NATO operations but not currently an area of active research;
- List Two TICs are important to future NATO operations and are currently supported by an active research effort by more than one or two NATO Nations; and
- List Three TICs are of lower importance to future NATO operations.

The resulting sub-sets consisted of 40 List One TICs; 122 List Two TICs; and 193 List Three TICs. The List One TICs became the focus of Phase IV and V of the study, and for this reason the List One TICs are presented in Annex C, and for completeness the entire JO 2030 Capability Set ordered by Theme, then Issue and then Capability can be found in Annex D.

Figure 5-2 shows the distribution of the List One TICs across the Themes. Theme 16 – Political Transformation had the most TICs within the sub-set selected, whereas Theme 15 – Cost Escalation and Theme 18 – Super-Empowered Individuals had no TICs in the sub-set.

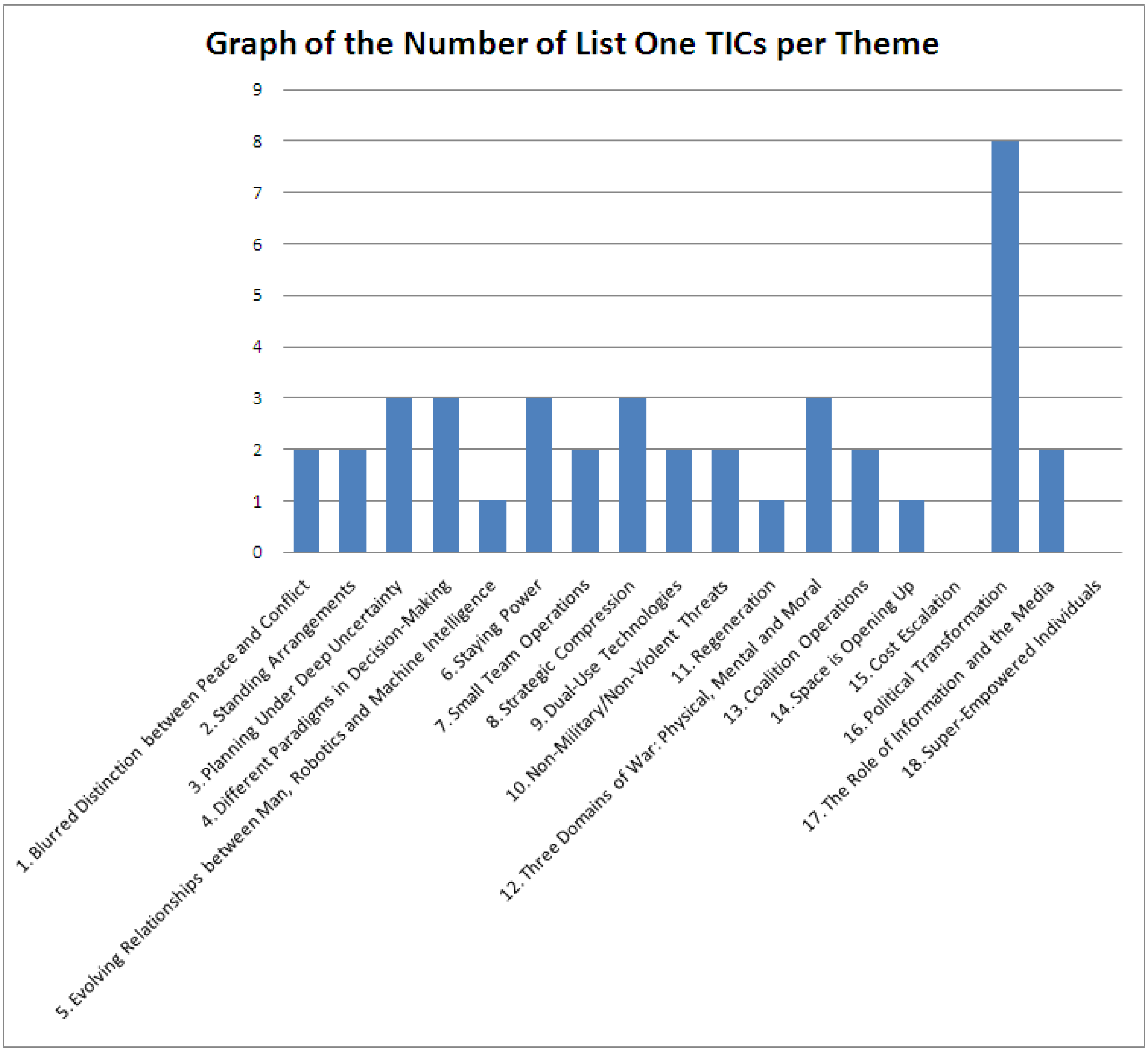

Figure 5-2: Graph of the Frequency of Selected List One TICs Appearing in Each Theme.

To identify the main semantic concepts across all TICs, the Study Team text mined all of the text of the Themes, Issues, and the Capability statements using the Wordle website. The Wordle website allows users to upload text which is data mined and output in the format of a picture. The size of a word relates to its frequency of occurrence, the colour and orientation of the words is purely aesthetic.

Figure 5-3 shows the Wordle for all of the JO 2030 Theme-Issue-Capability triplets. Some of the more interesting frequently occurring words were “information” (most frequent at 197 occurrences), “environment” (142), and “risk” (104).

Figure 5-3: Wordle Output of the Most Frequently Occurring Words in the Theme-Issue-Capability Triplets from the JO 2030 Capability Set.

Chapter 6 – IDENTIFYING TECHNOLOGY FOCUS AREAS

6.1 INTRODUCTION

As the study arrived at Phase IV and due to the limited resources provided by the participating Nations and representatives, it was agreed that the focus of the search effort in this phase of the study would be the 40 List One Set of TICs.

The Study Group, the majority of whom came from operational research and defence planning backgrounds, recognised that it did not have the expertise resident within the Group that would enable it to identify all the research opportunities that would match the needs of the List One Capabilities. Thus, the Study Group concluded that it would need to look elsewhere and this led to a decision to employ three methods of searching for solutions, namely:

- An effort to tap into the expertise across the NATO Research and Technology Organisation;
- An effort to conduct a number of literature searches; and
- Efforts to host a number of Solution Solicitation Sessions (SSSs).

Each of these is described in more detail below. At the conclusion of these efforts, the study progressed through to Phase V, a Multi-National Exercise which proved to be a successful and informative validation effort of the study’s methodology and results.

It also is worth mentioning that, while the study initially set out to search for solutions to close future capability gaps, over the course of Phases IV and V it became evident that these were not easy to find or identify. In looking back, this study would observe that solutions often only materialise in hindsight – that they become apparent over time and often after many incremental, evolutionary, revolutionary, and integrative changes or improvements to a system or to a system-of-systems have resulted in the development and delivery of a new ‘solution’ to a problem.

Thus, while the study initially sought solutions to capability gaps, few were actually found, and during Phase IV and V of the study the results that were generated were more along the lines of areas of explorations or, as the study choose to call them, Technology Focus Areas (TFAs). To be clear, there was no firm definition of what was and what was not a TFA. Broadly speaking, TFAs represent potential areas of scientific, technological, or research-orientated areas of investigation that could advance the understanding of, or potentially lead to solutions to, the List One TICs.

6.2 RTO OUTREACH

The objectives and intentions of the JO 2030 Study were briefed to all the other RTO Panels on two or more occasions and invitations extended to these Panels to send representation or to participate in a meaningful way in Phase IV and V of the study. However, only one Panel took any action of note. And so, this was an area that, despite many efforts to reach out across and draw upon the expertise resident within the RTO Panels, provided only limited results. The limited amount of success that was achieved resulted largely from the individual interaction with a representative from the SCI Panel and the JO 2030 Study Group over the course of a number of meetings. Since the JO 2030 TICs were acknowledged by the Study Group as being both relevant and underdeveloped, this difficulty in mobilizing the participation of the other RTO Panels suggests that the structure of the RTO Panels may not adequately cover all scientific disciplines that could contribute to addressing future capability shortfalls.

A second area of collaboration was the efforts undertaken in earlier Phases of the study to coordinate and avoid duplication of effort with the SAS-062 Disruptive Technologies Study. The SAS-062 effort was nearing completion at the time that the JO 2030 Study was beginning. An understanding developed between the two studies, and is was generally accepted that SAS-062 was working at higher TRLs and likely to be deployable in the 2 – 10 year time frame whilst JO 2030 was working more with technologies that were at the lower end of the scale of TRLs, which might mature and be ready for deployment in the 20 – 30 year horizon. As Phases IV and V of the JO 2030 Study evolved, this demarcation held and there was very little, if any, overlap between the two studies.

6.3 LITERATURE SEARCHES

Literature searches were conducted from databases belonging to the RTO, Defence and Research Development Canada (DRDC) and Defence Technical Information Centre (USA) as well as some material from participating Nations and from participants at ATC. The bibliography of the material that was gathered from the Literature Search is included at Annex E. There was a large amount of data and information to consider. A summary of the material and ideas extracted from the literature review was written and combined with the initial results from the SSSs as read ahead material for the MNE participants (Annex F).

6.4 SOLUTION SOLICITATION SESSIONS

A Solution Solicitation Session was intended to be a short, half to one full day, focussed meeting with experts in one or more areas of science or research linked to the List One TICs. A total of 25 sessions were conducted in seven different NATO countries leveraging the expertise of technologists, researchers, defence planners, and industry specialists. Each session was aimed at identifying research and technology opportunities that could address the List One TICs. Information on the 25 sessions conducted is presented in Table 6-1.

Table 6-1: Table of 25 Solution Solicitation Sessions Held in 8 Nations from September 2008 – July 2009.

S #	Group	Date	Location	Country	JO 2030 Facilitators
S1	Washington	16-Sep-08	Washington	USA	Mr Massel and ACT
S2	DRDC Halifax	1-Oct-08	Halifax	CAN	Mr Massel and Study Group
S3	CFPS Dalhousie	2-Oct-08	Halifax	CAN	Mr Massel and Study Group
S4	Oslo	20-Nov-08	Oslo	NOR	ACT
S5	Oslo	21-Nov-08	Oslo	NOR	ACT
S6	Bucharest	15-Oct-08	Bucharest	ROM	ACT
S7	Bucharest	15-Oct-08	Bucharest	ROM	ACT
S8	Bucharest	15-Oct-08	Bucharest	ROM	ACT
S9	Czech rep	28-29 Jan 09	Prague	CZH	LCol Pikner
S10	Czech Rep	16-Apr-09	Brno	CZH	LCol Svejda
S11	Brussels	27-Jan-09	Brussels	BEL	LCol Micha
S12	DRDC Valcartier	12-Feb-09	Quebec City	CAN	Mr Massel
S13	DRDC OCS	16-Feb-09	Ottawa	CAN	Dr Adlakha-Hutcheon & Mr Massel
S14	NIAG Rome	19-Feb-09	Rome	ITA	Mr Massel & Mr Giaccari
S15	NURC	26-Feb-09	La Spezia	ITA	ACT
S16	DRDC OCS #2	10-Mar-09	Ottawa	CAN	Dr Adlakha-Hutcheon & Mr Massel
S17	Kingston	14-Apr-09	Kingston	CAN	Dr Adlakha-Hutcheon & Mr Massel
S18	DRDC Ottawa	13-May-09	Ottawa	CAN	Mr Massel
S19	CF Legal Branch	15-May-09	Ottawa	CAN	Mr Massel & Dr Adlakha-Hutcheon
S20	CF DFSA	12-Jun-09	Ottawa	CAN	Dr Adlakha-Hutcheon & Mr Massel
S21	DRDC CORA Strat Analysts	22-May-09	Ottawa	CAN	Mr Massel
S22	DRDC Suffield	19-May-09	Suffield	CAN	Mr Massel
S23	ONR Global London	26-May-09	London	UK	Mr Massel
S24	DRDC Toronto	30-Jul-09	Toronto	CAN	Mr Massel
S25	Rome	16-Jul-09	Rome	ITA	Mr Giaccari

Over the course of the 25 Solution Solicitation Sessions a number of different approaches were taken in hosting and running the session. Depending upon the range and type of expertise that was expected in the target audience of a given session, the time available, and the predilection of the Session Facilitator one to many TICs were chosen for discussion on a session by session basis. As well, in order to leave as much flexibility in the hands of the Session Facilitator the choice of matching the chosen TICs to the target audience was left to the Facilitator. The consequence of this approach was that some TICs were discussed in many sessions and other TICs were discussed rarely or, in some cases, not at all. This was in part a reflection of the challenging nature of these less well understood TICs and the fact that some of these TICs do not immediately lend themselves to current defence and industrial scientific and technological pursuits. A record of the TICs that were discussed and explored across the 25 Solutions Solicitation Sessions is presented in Table 6-2 on the next page.

Table 6-2: Table of List One Capabilities Explored by Various Solution Solicitation Sessions.

Capability		Washington S1	DRDC Halifax S2	CFPS Dalhousie S3	Oslo S4	Oslo S5	Bucharest S6	Bucharest S7	Bucharest S8	Czech rep S9	Czech Rep S10	Brussels S11	DRDC Valcartier S12	DRDC OCS S13	NIAG Rome S14	NURC S15	DRDC OCS #2 S16	Kingston S17	DRDC Ottawa S18	CF Legal Branch S19	CF DFSA S20	DRDC CORA Strat Analysts S21	DRDC Suffield S22	ONR Global London S23	DRDC Toronto S24	Rome S25
Capable of shaping the 'home front' in the grey zone between peace and conflict	1																					√				
Capable of generating coherent and integrated policy options	0																									
Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities	2																			√					√	
Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations	0																									
Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	5	√	√						√						√								√			
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	0																									
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	4			√		√		√													√					
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	3			√																			√		√	
Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach	0																									
Capable of acting in dynamic 'value chains' with a variety of potential partners	4				√				√														√		√	
Capable of defining unambiguous Rules Of Engagement (ROEs)	5								√								√	√		√			√			
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	2			√			√																			
Capable of developing flexible and adaptive leaders	2																				√		√			
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	0																									
Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	4	√	√				√																√			
Capable of adapting organizational structures to reflect changing circumstances and evolving objectives	3											√											√		√	
Capable of gathering, analysing and disseminating lessons learned in a timely fashion	1																	√								
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	0																									
Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	3	√	√															√								
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	2							√													√					
Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology	6						√						√	√				√					√			√
Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment	0																									
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	4			√		√						√											√			
Capable of researching and executing strategies that mitigate the need for large numbers of forces	3							√					√				√									
Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment	0																									
Capable of acting without access to cyberspace	1						√																			
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	4			√					√									√							√	
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	2			√					√																	
Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	3	√	√																			√				
Capable of acting without access to space assets	7	√			√			√				√	√		√			√								
Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	3	√	√																						√	
Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa	2																					√			√	
Capable of measuring, analysing, predicting and anticipating risk within a complex environment	1			√																						
Capable of conducting civil-military cooperation in an inter-agency environment	5					√				√												√	√		√	
Capable of formulating and executing shared and realistic actions	0																									
Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements	4														√	√						√			√	
Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	2		√																						√	
Capable of undertaking in-depth foresight analysis to develop models of the future security environment	2					√																√				
Capable of designing effective media strategies	3									√													√		√	
Capable of exploiting information space for disinforming opponents	0																									

It was over the course of these Solution Solicitation Sessions and during the JO 2030 Study Group meetings that took place concurrently, that it became apparent that finding 'solutions' would be too difficult and that working with Technology Focus Areas (TFAs) would be primary output of this effort.

6.5 OVERALL RESULTS OF THE PHASE IV SEARCH EFFORT

Of the three approaches that were pursued during Phase IV to try and identify solutions that matched the List One Capability needs, by far the most successful were the Solution Solicitation Sessions. Even after the decision was taken to work only with the 40 List One TICs, which amount to a little more than 10% of the JO 2030 Capability Set, this much shortened list remained a broad and challenging list of future capabilities which in turn begged for input and insights that could potentially come from a wide range of scientific and technical expertise. Opportunities to engage with the expertise resident in the other RTO Panels proved hard to establish; the results of the literature searches tended to be too broad and not focussed on the study's needs; which left the opportunity to tap the local or specific knowledge and insights from a wide range of expertise in attendance at a variety of Solution Solicitation Sessions as the most successful effort that was undertaken in Phase IV.

At this point in the study, inputs and information capturing efforts remained diffuse and diverse. Making sense of it all in advance of the planned MNE proved to be a challenge. As was previously mentioned, one of the efforts to pull together what had been collected up to this point was a preliminary analysis of the Phase IV research efforts that can be found in Annex F.

6.6 PHASE V – THE MULTI-NATIONAL EXERCISE

During the final phase in this study, the Team conducted a 2½ day Multi-National Exercise (MNE) at the offices of the Assembly of Western European Union and the European Union's Institute for Security Studies in Paris, 8 – 10 September 2009. Approximately 25 experts with a range of academic, military, industrial, and defence science backgrounds from 11 different NATO Nations and 4 PfP Nations participated in the event and were joined by 14 members of the Study Group and 4 other members of the RTA. This Group lent their insights and expertise to the task of reviewing and adding to the list of Technology Focus Areas that had been developed for the List One TICs during Phase IV. The agenda and a list of the attendees of the MNE are included in Annex G.

6.7 LIST ONE CAPABILITIES AND ASSOCIATED TECHNOLOGY FOCUS AREAS

With the completion of the Phase V MNE, the JO 2030 Study Group had pulled together a long list of Technology Focus Areas that were associated with the 40 List One TICs. At this point in the study it was decided to shift from viewing the TFAs by virtue of their association with a given TIC to simply viewing the TFAs in association with a Capability. Within the JO 2030 Capability Set a number of specific Capabilities can be found to repeat themselves across different Theme-Issue combinations. In developing the JO 2030 Capability Set this was accepted as a useful 'one Capability to many Themes-Issues' construct helped in generating the set. During Phase IV it was again useful to continue to employ the TIC construct because the inclusion of Theme-Issue information provided context and meaning to a given Capability particularly when trying to imagine this Capability in a futuristic 2030 construct. However, as the list of TFAs grew it became apparent that the TFAs were associated mostly with a given capability and that the Theme-Issue context brought little added value to understanding or analysing the TFAs. The Theme-Issue contextual information was very helpful in explaining a capability and in turn associating that capability with a TFA; however once a TFA had been associated with a capability its link back to a given Theme-Issue lost meaning or perhaps more to the point the Capability-TFA association once made stood on its own.

Thus, in the planning for the MNE it was decided to switch the grouping of the TFAs from the List One Set of 40 TICs to a shorter set of 25 List One Capabilities. The 40 List One TICS contained a total of 23 unique Capabilities and two other Capabilities which were associated with 6 and 11 different TICs respectively. The List One Capabilities list is presented in Table 6-3.

Table 6-3: Table of List One Capabilities List.

1)	Capable of shaping the ‘home front’ in the grey zone between peace and conflict.
2)	Capable of generating coherent and integrated policy options.
3)	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities.
4)	Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations.
5)	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour.
6)	Capable of measuring, analysing, predicting and anticipating risk within a complex environment.
7)	Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach.
8)	Capable of acting in dynamic ‘value chains’ with a variety of potential partners.
9)	Capable of defining unambiguous Rules Of Engagement (ROEs).
10)	Capable of developing flexible and adaptive leaders.
11)	Capable of adapting organizational structures to reflect changing circumstances and evolving objectives.
12)	Capable of gathering, analysing and disseminating lessons learned in a timely fashion.
13)	Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology.
14)	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment.
15)	Capable of researching and executing strategies that mitigate the need for large numbers of forces.
16)	Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment.
17)	Capable of acting without access to cyberspace.
18)	Capable of acting without access to space assets.
19)	Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa.
20)	Capable of conducting civil-military cooperation in an inter-agency environment.
21)	Capable of formulating and executing shared and realistic actions.
22)	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements.
23)	Capable of undertaking in-depth foresight analysis to develop models of the future security environment.
24)	Capable of designing effective media strategies.
25)	Capable of exploiting information space for disinforming opponents.

A comprehensive list of the origin of the JO 2030 TFA Set as gathered from the Solution Solicitation Sessions and the MNE and grouped by the List One Capability list can be found in Annex H. From this set of results at total of 247 TFAs were extracted. This list of 247 TFAs can be found in Table H-4 as the JO 2030 list of List One TFAs also in Annex H, and was subjected to further analysis as discussed in the next section.

Chapter 7 – RESULTS

7.1 SUMMARY OF THE INITIAL FINDINGS

The initial findings of the study revealed that some of the thorniest currently under explored problems facing the Alliance are those requiring social science research, an area of research that is not typically a major focus of NATO RTO studies. These findings pointed to the need for better decision-making, for holistic knowledge bases, and for new organizational concepts that deal with complex and ambiguous moral and legal environment which, in turn, imply the need to engage cognitive psychologists, management theorists, legal scholars and ethicists. Further reflection on the results offered a number of other findings.

One issue is that many of the Capabilities identified as critical for successful NATO operations in 2030 do not lend themselves to “hard” technological solutions. NATO must look to the fields of economics, psychology, sociology, management science, political sciences, ethics and legal studies for insights into how to grapple with problems such as:

- Measuring, analyzing and predicting risk in a complex environment;
- Generating coherent and integrated policy options; and
- Developing adaptive organizational structures to reflect changing circumstances and evolving objectives.

Another interesting area is algorithm development to support a host of applications, including data fusion, search and pattern recognition, robotics, and information and knowledge management. Also, the role and placement of the human in the loop will continue to be a challenging issue and potentially a limiting factor or even a weak point in the years leading to 2030. Technologies supporting timely decision-making amidst complexity will be important.

It is also observed that the trend toward commercial leadership in many key technologies will continue to hold. Thus, while there is little doubt that areas such as battery improvement, faster processors, increased bandwidth capacity, and lightweight durable materials will be important, much of the progress in these fields will be driven by industry. Coupling this with projections of declining military budgets in the future results in the need to stay abreast of commercial developments in a wide range of products in order to maximize the return of national research investments.

Another area of interest with many overlaps into a variety of applications is studies on cognition and culture in an anthropological context. A better understanding of how the mind works, and its limitations could be highly relevant to understanding and assisting decision-making in the future; to how the ‘man machine interface’ evolves with the coming world of robotics and artificial intelligence; and to how military operations involving many agents and agencies evolve and adapt.

7.2 TECHNOLOGY FOCUS AREAS AND FIELDS OF SCIENCE

In addition to this broad initial summary, a more careful analysis of the TFAs was undertaken. A review of the 247 TFAs revealed that some of the TFAs were repeated or were similar across a number of the 25 List One Capabilities. As well, these TFAs tend to fall into one or more broader Fields of Science and an effort was made to associate each of the TFAs with one or more of these Fields of Science.

For the purposes of this analytical effort the Study Group considered employing the European Defence Agency Technology Taxonomy [10], but it was found not to be broad and comprehensive enough for the range of TFAs that had been identified in the JO 2030 Study. Instead, the Study Group agreed to the use of the Fields of Science as provided by Wikipedia [11]. Wikipedia defines Fields of Science as widely-recognized categories of specialized expertise within science, and typically embody their own terminology and nomenclature. Each field will commonly be represented by one or more scientific journal(s), where peer reviewed research is published. These Fields of Science served as a potential link between the TFAs that had been indentified by the study and broader areas of research and investigation. Table 7-1 is a list of the Fields of Science that were employed in this analysis and Annex I contains a more detailed or higher fidelity list of the Fields of Science that underlies the Table 7-1 summary list of the Fields of Science.

Table 7-1: Table of the Fields of Science.

- 1 Natural sciences
  - 1.1 Physical Sciences
    - 1.1.1 Chemistry
    - 1.1.2 Physics
    - 1.1.3 Astronomy
    - 1.1.4 Earth sciences
    - 1.1.5 Environmental sciences
  - 1.2 Life Sciences / Biology
- 2 Formal sciences
  - 2.1 Computer sciences
  - 2.2 Mathematics
  - 2.3 Statistics
  - 2.4 Systems science
- 3 Social sciences
  - 3.1 Anthropology
  - 3.2 Economics
  - 3.3 Psychology
  - 3.4 Geography
  - 3.5 Philosophy
  - 3.6 Political science
  - 3.7 Sociology
- 4 Applied sciences
  - 4.1 Agronomy
  - 4.2 Architecture
  - 4.3 Cognitive sciences
  - 4.4 Education
  - 4.5 Engineering
  - 4.6 Health sciences
  - 4.7 Management
  - 4.8 Military Science

An effort to associate each of the 247 TFAs with one or more of these Fields of Science was undertaken and involved asking the following question of each TFA:

> *If a researcher wanted to know more about this particular TFA which Field or Fields of Science would this researcher turn to?*

As an example the first TFA, “Conflict Studies and Underlying Drivers”, was linked to three Fields of Science of:

- Anthropology;
- Psychology; and
- Geography.

At first look geography might seem an odd selection here; however, geography includes such Fields of Science as human, cultural, political, social, and behavioural geography – all of where considered to be relevant to this TFA. This exercise was repeated for the entire set of TFAs and the end result is a table of List One TFA associated to one or more Fields of Science which can be found in Table J-2 of Annex J. A summary of this table, providing the frequency with which a given Field of Science is associated with the List One TFAs is presented in Table 7-2.

Table 7-2: Summary Table of the Count of Fields of Science Associated with List One TFAs.

#	CAPABILITY DESCRIPTION	Natural sciences	Physical Sciences	Chemistry	Physics	Astronomy	Earth sciences	Environmental sciences	Formal sciences	Computer sciences	Mathematics	Statistics	Systems science	Social sciences	Anthropology	Economics	Psychology	Geography	Philosophy	Political science	Sociology	Applied sciences	Agronomy	Architecture	Cognitive sciences	Education	Engineering	Health sciences	Management	Military Science	Total
1	Capable of shaping the 'home front' in the grey zone between peace and conflict			1						1				4	4	2	2	1			2				2				1		20
2	Capable of generating coherent and integrated policy options																														0
3	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities									2	1	1	6	2							1						1		4	2	20
4	Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations								1	1			2														2		1	1	8
5	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	2							13	36	6		10	2	8	3	4	1	2						6		15	1	1	5	115
6	Capable of measuring, analysing, predicting and anticipating risk within a complex environment								14	9	1		6	2	3	9	3	2	2	2	3				7		5		13	6	87
7	Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach									1			3	1											2		1		2	1	11
8	Capable of acting in dynamic 'value chains' with a variety of potential partners								1				1	2		1	1		1	1									3	2	13
9	Capable of defining unambiguous Rules Of Engagement (ROEs)			2					4	3			4		1				4	1							9		1	1	30
10	Capable of developing flexible and adaptive leaders								2	4			4	2	5	2	1	2	1		2				2		2		3	2	34
11	Capable of adapting organizational structures to reflect changing circumstances and evolving objectives						1		1	13			5		1	2	6	1			1				6		1		3	4	45
12	Capable of gathering, analysing and disseminating lessons learned in a timely fashion								1	11			1	2	1		2								4		2		1	1	26
13	Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology								2				1	2	1	1									1		2		3	2	15
14	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment																														0
15	Capable of researching and executing strategies that mitigate the need for large numbers of forces							1		3			4		2	1			2								4	1	1	5	24
16	Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment													1																1	2
17	Capable of acting without access to cyberspace									2	1		2														1				6
18	Capable of acting without access to space assets			1		1			3	6			3												1		10		1	2	28
19	Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa														1		1	1		1									1	1	6
20	Capable of conducting civil-military cooperation in an inter-agency environment								4	3			2	5	6	2	6	1			3				6	2	2		6	5	53
21	Capable of formulating and executing shared and realistic actions																														0
22	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements	1		3					1	8	2		6	2	1				1						2		8	1	1	2	39
23	Capable of undertaking in-depth foresight analysis to develop models of the future security environment			1					1	5	3	1	4	1	1	1													3		21
24	Capable of designing effective media strategies													1	1	1	2				2				2					1	10
25	Capable of exploiting information space for disinforming opponents																														0
Grand Total		3	0	8	0	1	1	1	48	108	14	2	64	29	36	25	28	9	13	5	14	0	0	0	41	2	65	3	49	44	613

Working from the information in Table 7-2, a list of the Top Ten Fields of Science, Table 7-3, was deduced. This short list of the Top Ten Fields of Science provides some indication of which Fields of Science could offer the most promise to provide improvements or to lead to solutions to one or many of the List One TFAs. There are, of course, no guarantees that this will occur. A novel, creative, or inventive discovery in another field could well lead to an equally novel or creative solution to any of a number of challenges; however, it is offered that for every novel and creative solution that will arise, many more solutions will evolve from a process of incremental improvement and integration along known or logical associated avenues of inquiry and investigation; such is the nature of research and development. Thus, it is reasoned that this list of the Top Ten Fields of Science merits closer scrutiny and offer a good indication of areas of research investment that, in turn, may advance possible solutions to the most challenging, currently unexplored capabilities that NATO Nations will require in the coming years.

Table 7-3: Table of the Top Ten Fields of Science that were Associated with List One TFAs.

Field of Science	Number of List One TFAs Linked to a Field of Science
Computer sciences	108
Engineering	65
Systems science	64
Management	49
Formal sciences	48
Military science	44
Cognitive sciences	41
Anthropology	36
Social sciences	29
Psychology	28

Chapter 8 – DISCUSSION AND RECOMMENDATIONS

8.1 DISCUSSION OF THE STUDY RESULTS

While the study produced three major outcomes and each merits some discussion in the following section, in general and overall, it first should be noted that a major challenge faced throughout this study was attempting to think and conceive of a future reality that is 20 years out. The study's participants spent many hours reflecting on past changes, current realities, the changing speed and progress of technological advancement, and issues or problems that impact past and present NATO operations. But when it came to trying to conceptualize a future paradigm, the Study Group was constantly challenged in its ability to move away from these same past experiences and present day realities. The Study Group noted that as individuals they drew some insight from the world of science fiction and present day cinematic representations of any number of future eventualities, but while this helped to place the participants in some future tomorrow, it never left the Study Group with a solid agreement as to what the future tomorrow would be like. In summary, thinking about the future was ever a major challenge for this Study Group and, accordingly, it makes only a limited claim that it got any of it right.

8.1.1 Thematic Analytical Approach

A deliberate effort was made to avoid the study becoming a simple projection of today's situation. Rather, it was an effort to frame the problem in terms of what a distant tomorrow might look like and what NATO would need to do today to achieve success in such a tomorrow. This led to a set of Themes, which allowed for a creative and open-ended conceptualization of some of the less well understood, and more challenging dynamics and realities of future NATO Joint Operation. As such, the Thematic Analytical Approach and the 18 Themes are one of the main results of the JO 2030 Study. It was accepted that some of the challenges that are implicitly part of some or many of the Themes may never be solvable, but that did not prevent the study from attempting to frame them, trying to define them, and making an effort at addressing them in some way in terms of possible future research and technology support.

8.1.2 The JO 2030 Capability Set

The effort to take the 18 Themes, expand them into Issues and then associate them with Capabilities resulted in a large set of Theme-Issues-Capability combinations. When this set was then cross-checked and combined with the NATO Long-Term Capability Requirements that were defined and agreed to by NATO's staff at Allied Command Transformation the end result was the JO 2030 Capability Set of 355 TICs which is the second major outcome of the JO 2030 Study.

Clearly this is a large body of capabilities that defines a wide range of future NATO Joint Operations and as such has a very large scope and no small amount of inherent complexity associated with it. In undertaking to create this Capability Set it is important to appreciate that the JO 2030 Study is the first Long-Term Scientific Study to attempt to look at a NATO Operation as a Join Operation vice from an environmental (Army, Navy, or Air Force) specific perspective and that, in comparison to the post Cold War strategic environment of the mid 1990s which pertained during the conduct of the previous AGAR supported Long-Term Scientific Studies, the strategic environment that existed during conduct of the JO 2030 had undergone significant change – both of which added more layers of complexity to the study effort. Given the current strategic reality that pertained at the time of the study, the JO 2030 Capability Set includes the many capabilities that would be at the centre of a tried and true large scale military operation and it includes a set of what might be called edge capabilities that attempted to define NATO Joint Operational challenges and needs at the start and end phases on either side of the actual 'winning the war' phase of a traditional military operation.

A second point regarding this Capability Set is that, apart from the inclusion of ACT’s Long-Term Capability Requirements in this set, no effort was made to compare this Capability Set to other such capability sets that are know to exist at a national level.

A third point concerning the JO 2030 Capability Set is that the capabilities in this set were generally written as either Strategic or Operational level capabilities. To have attempted to expand this Capability Set down to the tactical level was beyond the resources and expertise that resided in the Study Group but could prove to be a useful field of exploration for future study efforts.

A fourth point is that the JO 2030 Study readily acknowledges that quantity has a quality all of its own but that this aspect of ‘capacity’ was not given much consideration over the course of the study as it was agreed that this is an aspect and reflection of national will and is already inherently a part of the NATO Defence Requirements Review and, as such fell outside the mandate of the JO 2030 Study.

A fifth point is that the sub-set selected for expansion, the List One TICs, was generated by the Study Group. Some confirmatory check that Group’s assessment of whether or not the TIC was supported by an active research should be considered, so that critical List Two capabilities might be promoted if necessary.

A sixth and final point is that the assessment of the TICs meant that a probability-risk assessment was conducted concerning the 2030 time frame; however, it is conceivable that some of these TICs will become problems well in advance of 2030, and so some additional work on the maturation of the problem outlined in the TIC might be required.

8.1.3 Technology Focus Areas and Associated Fields of Science

The third major output of the study is the set of List One Technology Focus Areas and the insights that can be gleaned from them in terms of possible future research and technology investments.

The first important note to make is that the results reported earlier in this report are not by any means a comprehensive set of research opportunities or priorities. Since the List One TICs represents a little more then 10% of all the TICs that make up the JO 2030 Capability Set it follows that there is another much larger set of TFAs that are as yet un-described and un-associated with the List Two and List Three TICs. It is an imbedded assumption of the JO 2030 Capability Set Prioritization effort that the TICs that were grouped in as List Two or List Three TICs already have, to some degree, notable research programs associated with them; but this is an assumption that clearly is open to challenge, and may well benefit from greater investigation. Finally, by virtue of selecting the most challenging sub-set of the JO 2030 Capability Set it is reasoned that this maybe where the greatest value or greatest opportunities for return on future research investment reside. Nonetheless advances that will offer equally great value and opportunity surely reside within the List Two or List Three TICs; however, the identification and association of these TICs with a set of potential TFAs fell beyond the scope of the resources available to this study and has been left to other, future efforts.

A second, more general point is the observation that there was tension in this set of results between the “system-of-systems” and “complex systems” approaches. System-of-systems thinking lends itself to a total control paradigm such that if all the inputs are understood and accounted for then all the outputs can be predicted and controlled; whereas, a complex system approach follows a line of reasoning such that all the inputs cannot be understood and accounted for and the output is inherently not predictable nor controllable. The study undertook to be cognizant of the system-of-systems view of a problem, but there is a sense that at least some of the List One TICs lend themselves to the realities of a complex system which in turn leads to a whole new set of approaches to developing solutions. In this light, it is recognized that some of the challenges included in the JO 2030 List One TICs were, by their very nature, difficult, dynamic and possibly intractable and enduring problems that have no amenable solution or desired and agreed to end-state.

A third point is that the TFA analysis and the associated Fields of Science are pointers in a direction towards a solution but are not necessarily on a direct path. In the world of research and development time, effort, and the ingenuity will be needed to take these pointers and from them find clear routes to solutions.

A final point is that even with a much abridged list of 40 List One TICs and 25 Capabilities some topics proved to be underappreciated such that they never caught the interest and attention of the various small panels of defence and defence industry scientific experts with which these TICs were shared. This points again to the challenges presented when trying to understand and advance TICs that are not currently part of mainstream military operations. As well, with no resources to go and search for relevant experts, the study was limited to those that chose to contribute.

8.2 DISCUSSION AND OBSERVATIONS ON THE STUDY OVERALL

In terms of the study itself many things worked and other aspects of it were less successful. In general the constant and reliable input from ACT, participating Nations and Agencies was a key to the successful completion of this study. The study employed a two tier format of a larger Study Group which met two to three times a year and a smaller Core Study Team of national and ACT representatives who agreed to offer a greater level of effort and met about twice as often. This working arrangement allowed the Core Study Team to progress work in-between the Study Group meetings and often to trial new ideas that could be advanced and pursued effectively in the larger Study Group meetings. The second notable success was working with national and agency representatives who all brought a willingness to work on the issues at hand and a broad range of defence planning expertise with them. A third key achievement was that a team of defence planning experts from across the Alliance was able to penetrate the future employing methods to expose problems that were generally acknowledged to have been given short shrift in past canonical efforts. A final notable dynamic that contributed to the success of the study was the strong support that was provided from the NATO RTA management and in particular the Systems Analysis and Studies Executive Secretary on staff with the NATO RTA.

There were, however, aspects of the study that could have worked better. In comparison to what is known of past LTSS, this study was constrained by the limited financial and human resources that were provided to it. Given the size and potential scope of the study’s mandate, over the course of the study it became evident that the format and staffing of the Core Study Team and the Study Group would not be sufficient to exhaustively complete the study mandate as originally envisaged. In all, for a study that was given strong support at the levels of the RTA and the RTB it, nonetheless, would have benefitted from greater support and participation, particularly from some of the major NATO Nations who were not well represented.

A second missed opportunity was the very limited success that the study had in attempting to take advantage of the scientific expertise that is resident across the RTO and the NATO Nations as a whole. When it came time to look for areas of research and technology that could link to the 40 List One TICs, the Study Group actively sought the input of domain experts in a number of Fields of Science. One natural place to look was to draw upon the expertise that resides in the various RTO Panels. Significant efforts were made to introduce the JO 2030 Study efforts to each of these Panels and solicit their participation; however, very little actual engagement resulted, either during the Phase IV outreach efforts or during the Phase V, MNE. Since the JO 2030 TICs were acknowledged by all member states represented in the Study Group as being both relevant and underdeveloped, this difficulty in mobilizing the right scientists suggests that the current structure of the RTO Panels may not adequately cover all scientific disciplines that could contribute to addressing acknowledged capability shortfalls.

A third aspect of the study that did not deliver on its original objective was the effort to search for ‘solutions’. This is most likely due to early overreach in terms of the study’s mandate. While a small group might be successful in developing a rich description of the future joint operating environment, and even determining the potential implications of such a future, ultimately developing viable solutions to such problems requires considerable subject matter expertise. A comparison of the types of people attending the SSS and MNE (defence analysts and planners, operators, scientists) with the problems (economics, cognitive science, anthropology, psychology, law, political science) illustrates this issue. So the study did come up short and could not derive technological solutions for these requirements; however, on the positive side, the study was able to establish the scientific disciplines where solutions might be found.

8.3 BROADER DISCUSSION OF THE STUDY OVERALL

A number of broader issues that merit comment and observation regarding JO 2030 and the use and state of Capability Based Planning across the Alliance in general are discussed in the following section.

Over the course of this study effort, the JO 2030 Study employed a broader concept of ‘capabilities’ and capability portfolios. In particular the study advanced the use and understanding of a capability along a number of lines of meaning including:

- Trying to be more capability focused, working with ‘the ability to…’ instead of ‘capable of …’ i.e., not being solution (either platforms or systems) focused;
- Working with capabilities that were more strategic and not just operational or tactical;
- Working with capabilities which were ‘soft’ as well as ‘hard’ capabilities;
- Being, not just military focused but more comprehensive, striving to work more across the entire DOTMLPFI chain and to extend out to a whole of government and, at times, a whole of society approach; and
- Extending this reach more forward to provide resilience (i.e., security through capabilities for others and not just for oneself).

The study efforts revealed that NATO Nations have very uneven capability derivation and development processes and capacities. A number of the capabilities that were derived over the course of the JO 2030 Study represent defence planning capabilities (i.e., balance of investment models, planning methods, and risk models). The Alliance has an opportunity to consider better ways to make such models more widely available. For example, NATO, through ACT, could adopt a greater role as a repository of benchmarking and ‘best practices’ in defence planning.

It would be fair to say that the early meetings of the Joint Operations Study could be frustrating – the scale of the problem to be overcome, the transient nature of the participants, and the intermittent opportunities to engage meant that the Joint Operations 2030 Team was trapped for a long time in a forming (storming loop[1]), unable to settle onto a strategy to employ. Finally, inspired by the strategic planning theories of Mintzberg and Waters, the Joint Operations 2030 Team settled upon a less ‘purposive’ and more ‘impressionistic’ approach as compared to more conventional and traditional long-term capability planning efforts. What this study has been able to demonstrate is the value of using multiple approaches to deriving the requirements set. The Thematic Analysis methodology, a more creative approach, complemented the more conventional mission-task derivation of the Bi-SC LTRS. The JO 2030 Study observed that the NATO capability development process lacked innovation and needed more creativity, and that the outputs of NATO capability development efforts writ large were existing ones or extrapolations of what we know.

The domain of defence planning would benefit from better capability taxonomies. The Study Group considered that the impact of taxonomies is often underestimated. As defence planning moves more towards capability ‘portfolios’ the value and impact of these taxonomies is expected to increase.

[1] Proposed by Bruce Tuckman in 1965, the “Forming – Storming – Norming – Performing” is a model of group development. Tuckman maintained that all of these phases were necessary and inevitable in order for a team to grow, to face challenges, to tackle problems, to find solutions, to plan work, and finally to deliver results.

There continues to be a need for more 'effects-based' thinking, not in terms of deterministic models but in terms of what is trying to be achieved, and what needs to done, changed or acquired for that to be achieved, particularly at the edges of an operation.

There is a need to find better ways to derive solutions to defence and security problems by leveraging not just the normal engineering dominated realm of applied sciences but throughout the sciences – including the natural, formal, and social sciences.

There is a need for more proactive capabilities and not just reactive, 'one-off' efforts or responses. These proactive efforts need also to be sustained efforts, largely by the 'Western' community and focused on particularly vulnerable regions or countries.

There is a need to find better ways to make the defence planning processes more 'adaptive' – not just for changing current contexts, but also for changes to future and prospective contexts.

There is an opportunity to move towards strategic defence management which would see stronger linkages between high-level policy parameters to capabilities to performance management.

8.4 RECOMMENDATIONS

At its final meeting the Study Group offered a number of recommendations that touch on the study itself and each of the three main results and point to possible follow on efforts. These recommendations are as follows:

- **The Study Methodology**

  In adopting a more needs-based or capability based approach towards the identification of required capabilities followed by a search for solutions approach, the JO 2030 Study applied a more creative and objective-based analytical approach. This was a notable departure from previous LTSS efforts which tended to be more a survey and technology extrapolation and technology validation based approach.

  It is recommended that this objective-based analytical approach be considered for use in future Long-Term Scientific Studies.

- **Themes and the Thematic Analytical Approach**

  It is recommended that:

  - NATO consider how to incorporate the Thematic Analytical Approach into the NATO Defence Planning Process;
  - NATO Nations consider the use of the Thematic Analytical Approach in their long-term strategic planning efforts; and
  - The Thematic Analytical Approach be used as an approach for exploring new or different views of how future capabilities could be identified. As such, this approach should be employed periodically by the NATO RTO.

- **The JO 2030 Capability Set**

  It is recommended that:

  - NATO consider how to incorporate the derived Capability Set into the results of the NATO Defence Planning Process; and

- The RTO consider further analysis of the Capability Set, since there remains a large sub-set of unexplored capabilities. These could be divided into smaller sets for further investigation or validation of current and future technology challenges.

- **List One Set of Technology Focus Areas and Associated Fields of Study**

  It is recommended that the List One Set of Technology Focus Areas and associated Fields of Study:

  - Should be refined once more by a multi-disciplinary group, possibly drawn from across the Panels within the RTO, and possibly as part of an effort to ascribe some level of importance to this list of TFAs;
  - Should be presented to the Armaments Groups and/or the NIAG to be used to guide future research and technology investment;
  - Should be considered as an indication of the potential need to re-align the RTO to address more completely the capability gaps and research opportunities identified in this study;
  - Could be mapped to the current and recent past RTO studies to the JO 2030 TFA list. This alternatively could also be attempted at the level of a given Nation's national research and technology efforts. Either of these would identify where work and effort is progressing in some of the TFAs and where there are gaps or lack of investment; and
  - Could be reviewed with a view to associating or identifying a given TFA as a potential disruptive technology.

Chapter 9 – CONCLUSIONS

The initial objective of the study was to indentify technologies that would notably enhance future NATO capabilities. Over the course of this effort the study produced three main outputs:

- An explorative Thematic Analytical approach for conducting the study;
- The JO 2030 Capability Set; and
- A Set of List One TFAs and associated Fields of Science that merit further consideration.

The Thematic Analytical approach employed a series of creative spirals to develop and agree to a set of 18 JO 2030 Themes in the context of a less 'purposive' and more 'impressionistic' philosophy. These Themes did not define the future, nor were they comprehensive in their scope, but rather they more richly informed a thought space that was used to examine potential capability requirements. They were meant to be thought provoking and to be clearly separate from well known and studied trends that many experts have already agreed will have an impact on future operations. As such, the Thematic Analytical approach was a deliberate effort not to validate the well-known problems of tomorrow but rather to raise the level of discussion of the not so well-known challenges that may develop or evolve over time.

The JO 2030 Capability Set was built up from the 18 Themes that were generated in the earlier phases of the study, and that were elaborated into 60 Issues and associated with 114 Capabilities the end result of which is a set of 355 Theme-Issue-Capability triplets that constitute the JO 2030 Capability Set. This set of capabilities incorporated the 38 Long-Term Capability Requirements from Allied Command Transformation's Long-Term Requirement Study and as a whole contains a range of traditional, warfighting capabilities through to some challenging or edge capabilities which would not normally be found in current day Capability Based Planning capability sets. Due to limits on the resources of the Study Group, the JO 2030 Capability Set was prioritized into three sub-sets or lists. In an effort to provide the best return on effort the study focussed the final phase of the study on the List One Set of TICs which were capabilities that the study considered would benefit from an improvement in level of capability, are important to future NATO operations, but are not currently an area of active research by most NATO Nations.

In the final phases of the study, the resources of the Study Group were concentrated on the List One Set of Capabilities which was a list of admittedly challenging and not necessarily resolvable future Capabilities. Working with a variety of research efforts, the JO 2030 Study compiled a list of 247 Technology Focus Areas. This list of Technology Focus Areas, at first look, point towards the need to investigate or seek advancement in many areas of social science research, algorithmic development, exploiting ongoing commercial advances across a number of technologies, and understanding the strengths and limits of human cognition. A second level analysis of the Technology Focus Areas resulted in an effort to associate them with one or more Fields of Science, the most frequently associated Fields of Science being:

- Computer sciences;
- Engineering;
- Systems science;
- Management; and
- Formal sciences.

This list of Fields of Science, or more precisely, the List of Top Ten Fields of Science, constitute the best indications of areas of research investment that, in turn, may advance possible solutions to the most challenging capabilities that lay ahead for the NATO Nations in the coming years, as identified by the JO 2030 Study.

Chapter 10 – REFERENCES

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[3] SAS-006, Land Operations in the Year 2020, NATO UNCLASSIFIED, NATO-RTO-TR-008, March 1999, 268 p.

[4] LTSS/46, Implications of New Technologies for NATO's Maritime Operations in 2015 (MO/2015). Phase 1 Report: Parts 1-4, NATO CONFIDENTIAL, AC/243(LTSS)TR/46A-D, 1996.

[5] Advisory Group for Aerospace Research and Development (AGARD), Aerospace 2020, NATO UNCLASSIFIED, AGARD-AR-360-Volumes 1 – 3, ISBN: NASA-19970017949 or 92-836-2001-1, April 1997.

[6] Joint Operations 2030 – Phase I Report: June 2007, RTO-TR-SAS-066-Phase-I, April 2011, 28 pgs.

[7] Mintzberg, H. and Waters, J., "Of Strategies, Deliberate and Emergent", *Strategic Management Journal* 6, 257-272, 1985.

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[9] Joint Operations 2030 – Phase III Report: The JO 2030 Capability Set, RTO-TR-SAS-066-Phase-III, April 2011, 126 pgs.

[10] European Defence Agency Technology Taxonomy downloaded from http://www.eda.europa.eu/webutils/downloadfile.aspx?FileID=249.

[11] http://en.wikipedia.org/wiki/Fields_of_science#Anthropology.

Annex A – LIST OF STUDY PARTICIPANTS

As with any study of this scale and duration, membership both in terms of individual, level of commitment, and national representation changed over time. The following is a list of the active participants of the study who all made some small to significant contribution to its progress. In terms of direct contributions to the authorship of the Final Report, again from a greater to a lesser extent this was a collective effort involving the Study Leader, major contributions from members of the Core Study Team and supportive contributions from many of the regular members of the Study Group. Following this list of study participants is a diagram of the level of formal national representation throughout the 5 phases of the study.

Study Leader	Mr. Paul Massel	CAN
Core Study Team		
	Mr. Mark Tocher	NATO ACT
	Mr. Peter Bretherton	NATO ACT
	Mr. Frank Bekkers	NLD
	Mr. Stephen de Spiegeleire	NLD
	Mr. Simon Purton	NATO ACT
	Cdr. Bruce Walker	NATO ACT
Study Group – Regular Members		
	Dr. Sigurd Glærum	NOR
	Mr. Viggo Lemche	DNK
	LtCol. Geert Leeman	BEL
	LtCol. Micha Christian	BEL
	Mr. Miroslav Svejda	CZE
	LtCol. Ivo Pikner	CZE
	LtCol. Bradley Kinneer	USA
	LtCol. Troy Harting	NATO RTO
	Mr. Ennio Giaccari	ITA
	Mr. Colin Wright	NATO ACT
	LtCol. Jens Hartman	NATO ACT
	Mr. Eric Verhoeff	NATO ACT
	Dr. Eric Ouellet	CAN
	Dr. Sandy Babcock	CAN
	Dr. Gitanjali Adlakha-Hutcheon	CAN
Study Group – Occasional Members		
	LtCol. Raymond Kurstitis	NATO ACT
	LtCol. Dean Black	CAN
	Mr. Mauro Varasi	ITA
	Lt. Kurt Mehmet	TUR
	Mr. Andreas Meier	DEU
	Mr. Heinz A. Schlichting	DEU
	Mr. Alistair Beedie	NATO DPP
	Mr. Freek-Jan Toevank	NLD
	Mr. John Barkley	USA

Study Group – Occasional Members (cont'd)

Mr. Marc Pinto	NATO NURC
Mr. Paolo Bartolomasi	NATO NC3A
Mr. Mathieu Eloy	FRA
Col. Cornel Barbu	ROU
Maj. Iulian Berdila	ROU
LtCol. Angelo Gervasio	NATO ACT
Mr. Bogdan Horvat	SVN

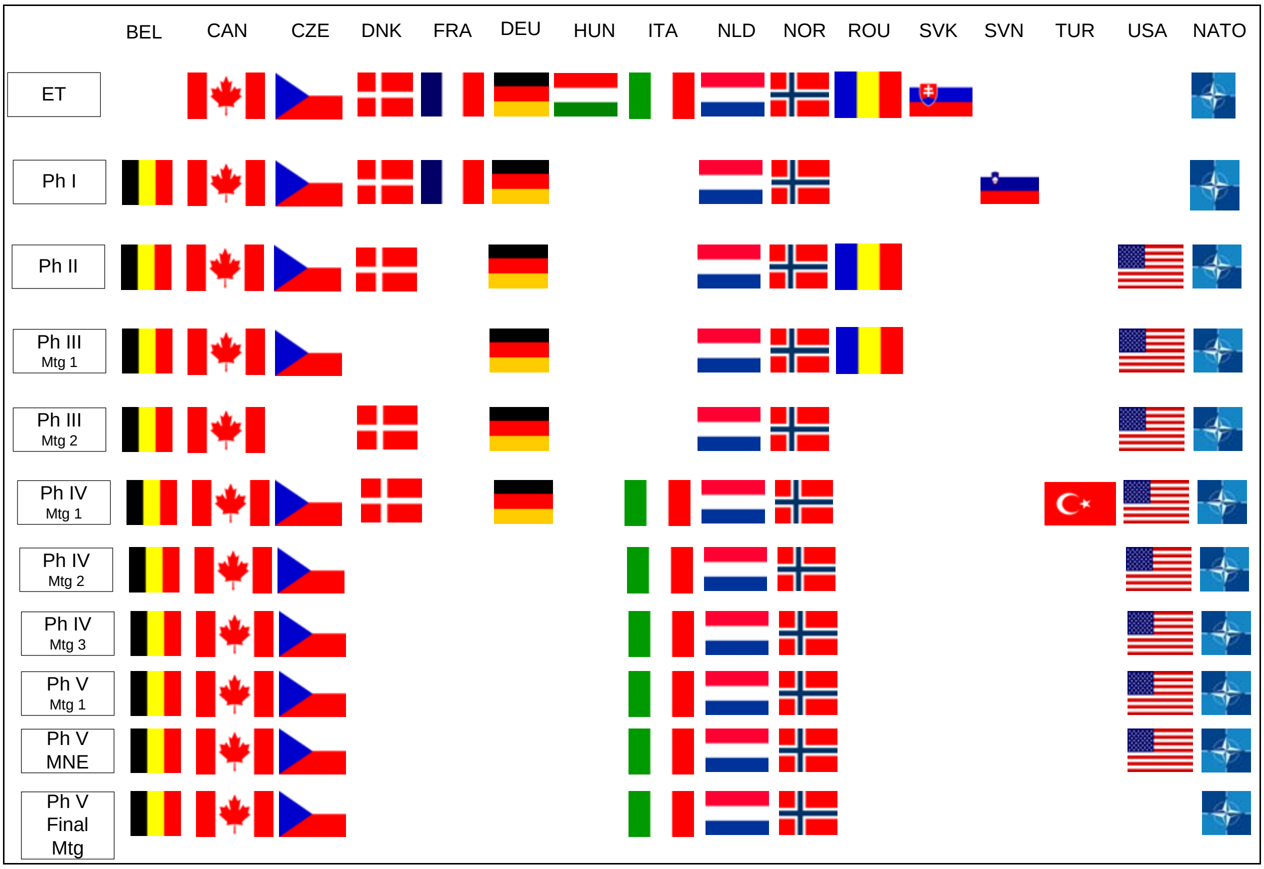

Figure A-1: JO 2030 Study Representation and Participation by Nation or Agency.

Annex B – THE JOINT OPERATIONS 2030 STUDY TERMS OF REFERENCE

B.1 ORIGIN

B.1.1 Background

Three major Long-Term Scientific Studies (LTSSs) were conducted in the 1990s under the auspices of the RTO and its predecessors. These studies addressed the impact of emerging technology on land, air and maritime operations, and recommended technical solutions to shortfalls in capability predicted to occur in the 2015 to 2020 time period. The results have had a significant influence on planning in NATO Strategic Commands and research and development activities in NATO bodies and Nations (e.g., Long-Term Capability Requirements, Programme of Work of the Main Armament Groups).

Since the completion of these LTSSs, the missions and role of the Alliance have changed significantly, and while many of the previous findings may still be applicable, a whole range of new operational factors and planning scenarios have appeared. Several years ago, the SAS Panel began to consider a variety of possible study activities under the general heading of ***Joint Operations 2025***.

Unfortunately, a lead Nation could not be found, so the Panel parked the idea.

At the RTB's September 2005 Meeting, the Chair of the NATO Army Armaments Group, speaking on behalf of the Main Armaments Groups, requested that the RTO conduct an LTSS on Joint Operations 2030. Subsequently, the RTA Director, on behalf of the RTB, asked the SAS Panel to investigate again the possibility of performing such a study.

Many Nations and NATO bodies seemed ready to participate, but the problem remained of a lead Nation. At the SAS Panel's November 2005 meeting, Canada volunteered to take the lead.

B.1.2 Terminology

The NATO Glossary of Terms and Definitions (AAP-6 2005) does not define the term 'Joint' but the definition of 'Joint Staff' implies that joint has the following meaning:

Joint	Formed from the contributions of two or more services of the same country.

The same source defines 'Operation' as:

Operation	A military action or the carrying out of a strategic, tactical, service, training, or administrative military mission; the process of carrying on combat, including movement, supply, attack, defence and manoeuvres need to gain the objectives of any battle or campaign.

This second definition seems rooted in the traditional sense of a military operation. These two definitions would lead to a definition of 'Joint Operations' in terms of the military action needed to gain the objectives of a campaign in which elements of at least two services are participating. This definition of joint would, however, guide the study towards technology that would only benefit system solutions that are useful for more than one service. Moreover, as the concept of the Effects-Based Approach to Operations (EBAO) is developed, it is recognized that military operations are conducted in the context of an integrated political, civil, military and economic approach to crisis and conflict management. EBAO's focus on the strategic end-state emphasizes the need to conduct the operation in a joint fashion to lever the full potential of all military and non-military capabilities. Within EBAO integration is such a necessity that any system solution cannot be thought of within the needs of a single service, but must be brought into the approach of a system-of-systems where mutual benefits can be considered in a wider context. Thus, the JO 2030 Study will employ the following more expansive definition of:

Joint Operations — Are all military actions that, within the context of an Effects-Based Approach to Operations, are required to support the attainment of a strategic end-state.

B.1.3 Justification and Military Benefit

As noted above, the missions and role of the Alliance have changed significantly over the past decade, and a whole range of new operational factors and planning scenarios have appeared. Recent military operations have highlighted the transformation of modern warfare in the following critical respects:

- Globalization of asymmetric threats to the security of Alliance Nations;
- Increased need for multi-national expeditionary operations outside NATO's traditional areas of responsibility;
- Drive towards further integration of single service capabilities into fully joint forces;
- Increased interest in multi-national interoperability and integrated force structures;
- Need for information superiority, flexibility and rapid employment of forces;
- Increased concern for protection and counteraction against weapons of mass destruction; and
- Need for improved networking of military command and control systems with those of civil authorities (police, homeland defence, etc.) and other multi-national bodies.

This Study will address all of the above issues. It will reflect the changed security environment, identify capability shortfalls that will persist in the longer term, consider the ways in which a more joint multi-national approach could be exploited, and address the impact of new and emerging technologies.

B.2 OBJECTIVES

B.2.1 Aim

The Study will offer insights into the impact that evolutions and revolutions in the applications of advancing technologies could have on the full range of capabilities that could be required in future NATO-led Joint Operations.

B.2.2 Scope

The study will:

a) Consider the impact that potential future global security environments could have on joint operations across a range of representative operations;

b) Determine the types of capabilities and identify projected capability gaps that may exist in this future environment; and

c) Consider how applied technologies will impact upon future capabilities and identify system concepts that could either close capability gaps or significantly enhance capabilities.

B.2.3 Phases

Phase I – Strategic Environment, Scenarios and CONOPS

Establish the fundamental parameters, guidelines and assumptions for the Study. Provide an agreed political-military context that underpins future work on capability requirements and solutions to these requirements. This effort will draw largely, but not exclusively on the current ACT Long-Term Requirements Study including the work on the Future Security Environment.

Conclude with Workshop and Phase I report.

Phase II – Establish the Projected Baseline Capabilities for NATO Key Force Structures in 2015

Determine the capabilities for joint operations that can be assumed to be in place in 2015 based upon, the MO 2015, LO 2020, and AO 2020 studies as well as the ongoing work that ACT is conducting on the NATO Defence Requirements Review.

Conclude with Workshop and Phase II report.

Phase III – Identify Capabilities for 2030 and Assess Capability Gaps

Reassess the capabilities that will pertain to the future security environments in the 2030 time frame and identify potential capability gaps between them and the 2015 Baseline Capabilities.

Including an Exploratory and Final Phase Workshop followed by a Phase III report.

Phase IV – Technology Assessment

Assess the impact of technological developments on capabilities, force structure and operational concepts, including the potential pay-off from breakthrough technology advances. Use results of wargames to be conducted under SAS RTG on ***The Impact of Potentially Disruptive Technologies*** and draw upon other evolutionary technological advances.

Including an Exploratory and Final Phase Workshop followed by a Phase IV report.

Phase V – Working Paper, Multi-National Workshop and Final Report

The emphasis in this phase will be to identify system concepts to close capability gaps or enhance capabilities. Follow the LTSS process, as outlined below.

Study Prospectus

The Study Director issues to Team and Panel Members a Prospectus for the contents of the Working Paper.

Intermediate Meeting of the Task Group

a) Discuss and agree the outline of the Working Paper based on the Study Prospectus; and

b) Identify appropriate national contribution/experts to the Multi-National Workshop (MNW).

Working Paper

The Study Director prepares a Working Paper for distribution to member Nations and NATO Military Authorities by the SAS Panel Executive. In the course of preparing the working paper, a Workshop may be needed. The Working Paper should be received by the SAS Panel Executive at least four months and preferably five months before the date of the MNW.

MNW Preparatory Meeting (usually at NATO HQ)

Review the tasks and composition of the MNW working groups and editorial party, depending on the topics addressed in the Working Paper and on the commitments of participation by the Nations.

Multi-National Workshop and Final Report

a) During the first week, a number of working groups discuss, amend and expand (if necessary) the various parts of the Working Paper, the necessary coordination being achieved during daily meetings of the Study Director with the Chairs of the working groups. Plenary sessions are also scheduled, chaired by the Study Director. Recommendations and conclusions from the study should be agreed by the whole group of experts at the end of the first week.

b) The second week is devoted to detailed editing and final preparation of the MNW Report by the editorial party chaired by the Study Director. The editorial party should not be put in the position of having to draw conclusions or make recommendations.

B.2.4 Schedule

Assuming a start date of 1 June 2006, the completion times for the Phases are estimated as follows:

PHASE	TIME PERIOD	REPORT DATE
Phase I	June – October 2006	January 2007
Phase II	November 2006 – June 2007	September 2007
Phase III	July – December 2007	March 2008
Phase IV	January – December 2008	March 2009
Phase V	January – December 2009	December 2009

B.2.5 Deliverables

The following reports will be produced during the study:

1) Phase I: Phase report describing the global security environment in the year 2030.
2) Phase II: Phase report assessing the baseline capabilities that can be assumed to be in place by 2015.
3) Phase III: Phase report assessing the capabilities that can be assumed to be need by and the capability gaps that will exist in the 2015 – 2030 time frame.
4) Phase IV: Phase report assessing the impact of emerging and breakthrough technologies on addressing the anticipated capability gaps.
5) Phase V: Study Prospectus, Working Paper and Final Report.

B.3 RESOURCES

B.3.1 Membership

The broad nature of the Study will require that members be drawn from several defence communities, including:

- Operational analysts;
- Scientific and technical experts; and
- Military officers.

Active participation of staff from key NATO bodies including ACT, Main Armaments Groups, and NC3B is also necessary. To plan and execute the study program, the JO 2030 Study will employ a Core Study Team and a larger Study Group.

The Core Study Team will be created to be the organizers and the directors of the study. The Study Director will lead the Core Study Team, and additional members will be contributed by Canada and ACT. Other Nations may also volunteer contributions to the Core Study Team.

The following Nations and NATO bodies either indicated that they were interested in this effort or sent representatives to the Exploratory Team Meeting, thereby signifying interest in participation: Canada (lead), Czech Republic, Denmark, France, Germany, Netherlands, Hungary, Romania, Italy, Norway, Slovakia, United Kingdom, and NATO ACT and the NATO Main Armaments Groups.

The Study Group will comprise the Core Study Team, designated Points Of Contact (POCs) from the participating Nations and interested NATO organizations, and national experts all of whom will be invited to participate leading up to and during each of the Workshops that are associated with the JO 2030 study phases. It is desirable to have both a scientific and a military POC from each participating Nation who will, for continuities sake, strive to work with the Study Group from start to finish. It is anticipated that the level of participation and the nature of the expert representation to each of the phases will, most likely, change to reflect the characteristics and objectives of each phase.

B.3.2 RTA Resources

RTO offered to support this study by assisting with the publishing of the various reports, providing the use of the web-based RTO WISE capability, assisting with organising some follow on meetings, and in organising the multi-national Workshop.

B.4 SECURITY CLASSIFICATION

The security level of discussions and some of the Phase reports maybe classified as need be. A version of the Final Report will be Unclassified and for Unlimited Distribution.

B.5 PARTICIPATION BY PARTNER NATIONS

Selected Nations may be invited to participate.

B.6 LIAISON

Close liaison will be required with ACT, the Main Armaments Groups, and NC3B, as well as with the SAS RTG on ***The Impact of Potentially Disruptive Technologies***. Information on the study will be provided to a number of NATO bodies including:

- The RTO Panels;
- The Senior National Logisticians Conference;
- NC3B;

- The International Military Staff;
- The Political-Military Committee;
- The NATO Standardization Agency;
- The Allied Joint Operations Working Group; and
- The NATO Air Defence Committee.

Annex C – THE LIST ONE SET OF TICs

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
1	**Blurred Distinction between Peace and Conflict**	The distinction between peace and conflict will become more blurred over the next decades as forces are used to accomplish traditional and non-traditional military missions in areas where a sustained threat will be present. This will be brought about by the globalization of the threat from terrorists, extreme fundamentalists, trans-national criminals and the weapons proliferation. There will be a shift from the sequential, phased, contiguous operations of the past to more continuous, simultaneous, parallel and distributed operations bringing military forces in contact with civilians, NGOs and indigenous security forces as well as a variety of opposing forces with diverse motives for conducting violent and non-violent actions.	1.1	**Peace and conflict coexist**	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without ‘a war going on’ might otherwise be withdrawn easily.	1.1.6	**Capable of shaping the ‘home front’ in the grey zone between peace and conflict**
			1.3	**Establish a workable division of labour / collaboration structure with other agencies**	Both with other governmental agencies, with NGOs and with private parties (see Theme 2). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders).	1.3.3	**Capable of generating coherent and integrated policy options**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
2	**Standing Arrangements**	Increasingly, in order to achieve its political and military objectives, the Alliance will operate within a comprehensive approach that will include a host of non-military supporting/supported organizations. The complementary capabilities of these partners will increase the overall capability of the Alliance to achieve its goals and, thus, must be included in the early planning and execution phases of operations to ensure their coherent application. These organizations will include NGOs, international and regional IOs, and private contractors which are increasingly being used to outsource non-core military capabilities. In order to successfully coordinate lines of development and to integrate these organizations into operations, it will be necessary to consider them within the operational planning process and to develop standing arrangements.	2.1	**Understanding different business models**	The real cost/benefit balance between contracting out a service vs. retaining in-house capability is difficult to measure and assess. It is also a dynamic balance, to a large extent driven by actual developments difficult to predict in advance.	2.1.2	**Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities**
			2.3	**Establish a workable division of labour / collaboration structure with external service providers**	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties. In various forms customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	2.3.8	**Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations**
Theme No	**Theme**	**Theme Summary**	**Issue No**	**Issue**	**Issue Description**	**Cap Req No**	**Capability Requirement**
3	**Planning Under Deep Uncertainty**	In the past, where conditions were relatively certain, Alliance defence and operational planning processes were deliberate and reflected 'strategy as design'. The fluidity and pace of change within the emerging globalised environment will increasingly demand that planning for Alliance operations will be done under conditions of deep uncertainty. Deep uncertainty is present when decision-makers do not know or cannot agree on – the current system model of how things fit together, prior probabilities, timing and cost. This will require a new suite of methods and analytical tools to support decision-makers in a 'strategy as process' manner to develop capabilities that are flexible, adaptable and robust.	3.1	**Dealing with intrinsic uncertainty**	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	3.1.6	**Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour**
			3.2	**Financial planning in Government**	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. Need for better ways of cash managing defence budgets? Might include strategies to deal with price fluctuations of required assets, such as commodities, e.g., through hedging strategies.	3.2.5	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
3	**Planning Under Deep Uncertainty**	In the past, where conditions were relatively certain, Alliance defence and operational planning processes were deliberate and reflected 'strategy as design'. The fluidity and pace of change within the emerging globalised environment will increasingly demand that planning for Alliance operations will be done under conditions of deep uncertainty. Deep uncertainty is present when decision-makers do not know or cannot agree on – the current system model of how things fit together, prior probabilities, timing and cost. This will require a new suite of methods and analytical tools to support decision-makers in a 'strategy as process' manner to develop capabilities that are flexible, adaptable and robust.	3.4	**Future structures**	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world may be examined for applicability. Outsourcing of services and rely on market adaptation mechanisms must be considered.	3.4.4	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
4	**Different Paradigms in Decision-Making**	The interconnected strategic environment of the 21st century has given rise to increased uncertainty and complexity. These emerging threads have been grasped by increasingly adaptive opponents. For the Alliance to be successful in the coming decades, it will have to undertake politically and militarily complex missions requiring a comprehensive approach. The interaction of changing circumstances in the strategic and operational environments will require different paradigms for decision-making. The complexity of future Alliance operations implies both quantitative and qualitative changes in the information and analytical support needed to make good and timely decisions. This could mean a move from the current paradigm of 'command and control' to one of 'focus and convergence'.	4.1	**Achieving common objectives**	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities reside in each of the organizations on achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	4.1.6	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**
						4.1.8	**Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach**
			4.2	**Information management**	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so.	4.1.10	**Capable of acting in dynamic 'value chains' with a variety of potential partners**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
4	**Different Paradigms in Decision-Making**	The interconnected strategic environment of the 21st century has given rise to increased uncertainty and complexity. These emerging threads have been grasped by increasingly adaptive opponents. For the Alliance to be successful in the coming decades, it will have to undertake politically and militarily complex missions requiring a comprehensive approach. The interaction of changing circumstances in the strategic and operational environments will require different paradigms for decision-making. The complexity of future Alliance operations implies both quantitative and qualitative changes in the information and analytical support needed to make good and timely decisions. This could mean a move from the current paradigm of 'command and control' to one of 'focus and convergence'.	4.2	**Information management**	In general, in a NEC environment, the traditional 'top-down' stream of information is augmented by a structural 'bottom-up' stream as well as a 'sideways' stream to Allies and 'other' agencies involved in the endeavour. (cont'd)	4.1.10	**Capable of acting in dynamic 'value chains' with a variety of potential partners**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
5	**Evolving Relationships between Man, Robotics and Machine Intelligence**	The exponential increase in computing power over the coming decades will lead to advances in artificial intelligence and the increasing use of robotics in military operations. The removal of the 'man from the loop' has beneficial effects, but also leads to questions on how to incorporate these advances into military operations. In operations where concerns over fratricide, defective targeting and collateral damage may override effectiveness, reluctance to deploy autonomous weapons system may persist. These advances demand changes in other aspects of military planning and execution brought about by the increasing speed of action available to autonomous systems.	5.1	**Moral, ethical and legal considerations of "human-out-of-the-loop"**	With the human out of the loop or not "at risk", the parameters for deciding on whether, where, when and how to wage war shift, at the political, strategically and operational/tactical level. What are the bounds/benefits of "automation" of military tasks? Winning the hearts and minds vs. safety of troops. Unmanned systems are typically used in dull, dirty or dangerous environments/ tasks. Psychological/moral aspect – is escalation potential higher if technology substitutes personnel?	5.1.3	**Capable of defining unambiguous Rules Of Engagement (ROEs)**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
6	**Staying Power**	It seems probable in the coming decades that Alliance military forces will be engaged on a more or less continuous basis in operations requiring significant numbers of the troops and weapons systems. To successful undertake such operations over time will require 'staying power' from Alliance Nations to remain engaged. There is a perception that Alliance forces currently do not possess sufficient staying power to engage a tenacious, adaptive enemy that seeks to keep Alliance forces engaged for a long period. Staying power must be developed at several conceptual levels: Political – political priorities and messages must be aligned to keep forces engaged; Operational – clever campaign design, use of technology, avoidance of too ambitious operations and increased forces; and Tactical – operations are typically undertaken by small units demanding improved equipment, protection and tactics.	6.2	**Facilitate political stamina**	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	6.2.6	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**
			6.3	**Establish a workable division of labour / collaboration structure with other agencies**	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the 'civ-mil loop' implied here goes beyond what is currently understood under the term 'CIMIC' (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not 'owned' by the military.	6.3.5	**Capable of developing flexible and adaptive leaders**
						6.3.7	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
7	**Small Team Operations**	In the future, military operations will increasingly be the domain of small units and teams. This will include variants of small fighting units and multi-disciplinary teams designed to address specific multi-faceted problems where security only forms part of the puzzle. These teams must generally work autonomous, independent operations for considerable periods of time. These teams must be able to shape the 'command intent' to develop solutions based on local conditions. They must be to 'sense and respond' independent of the larger force and adapt accordingly. This will drive modularity and networked requirements.	7.3	**Quick organisational learning cycle**	Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen out tried-out but proven ineffective strategies and to amplify effective emergent strategies. Sharing of 'situational understanding' to achieve coherent effects that are realistic in the given situation.	7.3.2	**Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour**
						7.3.4	**Capable of adapting organizational structures to reflect changing circumstances and evolving objectives**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
8	**Strategic Compression**	Strategic compression can be defined as the forming of unexpected casual relationships and breaking of expected causal relationships among the tactical, operational and strategic levels of conflict in the political, information, military and economic domains. This is a combination of the 'strategic corporal' and the 'tactical politician'. This is brought about by the interconnectedness of the globalised environment and the pervasiveness of the 24-hour media cycle supported by almost instantaneous information systems and networks allowing more people access to more information. The coalition nature of most future operations will increase the importance of controlling strategic compression to maintain the coherence/ viability of the coalition.	8.1	**Different causal relationships across the levels of conflict/ organisations/ endeavours**	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage / pressure affect the Issue?	8.1.2	**Capable of gathering, analysing and disseminating lessons learned in a timely fashion**
						8.1.6	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**
			8.3	**Morality and culture in coalition/ inter-agency endeavours**	If typical operations become more international and inter-agency (and even with external service providers), with (the need for) cooperation and collaboration pushing down to the tactical level (see, e.g., small team operations), several issues arise. The most fundamental issue might be the need to make an endeavour succeed with parties that act from quite diverse moral and cultural views.	8.3.1	**Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
9	**Dual-Use Technologies**	The concept of dual-use technology has most recently been used to describe the use of commercial technology for military purposes. With the bulk of research and development funds being expended on commercial development of technology, it very likely such developments will produce systems that will have a collateral military use. As scientific advances increase exponentially over the coming decades, there will be a requirement to monitor commercial technology for those developments that could give possible adversaries a mechanism to produce weapons systems.	9.1	**Spin-in of high quality, high pace innovation**	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	9.1.3	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**

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9	**Dual-Use Technologies**	The concept of dual-use technology has most recently been used to describe the use of commercial technology for military purposes. With the bulk of research and development funds being expended on commercial development of technology, it very likely such developments will produce systems that will have a collateral military use. As scientific advances increase exponentially over the coming decades, there will be a requirement to monitor commercial technology for those developments that could give possible adversaries a mechanism to produce weapons systems.	9.2	**Pace of technology development**	The pace of technology development is accelerating with a big jump ahead through the combination of advances in ICT, nano and bio technology and cognitive sciences. The variety of ways to wage war may drastically increase – faster than society can keep up in terms of legal and moral embedding of the phenomenon of war.	9.2.2	**Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
10	**Non-Military/ Non-Violent Threats**	The Alliance will face a variety of hybrid threats in the future. These include non-military threats where the source of the threat are non-conventional military forces and non-violent threats wherein, though it may be an enabler or an intended consequence of the action, violence is not an inherent element. These threats could come about through deliberate action, accidental occurrences or natural disasters. The cause and effect of these events is not limited by borders and are characterized by difficulty in prediction, detecting, localizing and typically involve little or no warning. They require trans-national coordination and inter-agency cooperation to resolve. Examples of these types of threats include: computer network attack; pandemics; mass migration; and natural disasters.	10.1	**Expansion of the mission set**	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	10.1.3	**Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment**
			10.2	**Risk prioritisation, balance of investments and scaling problem**	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There’s a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	10.2.2	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
11	**Regeneration**	Most NATO Nations have moved away from large forces toward smaller, more professional and more technologically intense forces as the threat from a peer competitor has receded over the last decades. The focus has moved to fighting short, intense battles against a medium sized force or conducting, what had been termed 'lesser included', missions such as counter-insurgency or stabilization/reconstruction. Regeneration refers to the ability of the Alliance to restore operational capabilities that formerly had been in its inventory or to develop a capability that is technically feasible but is not available for immediate use. Regeneration includes recognizing the need for taking action, conceptualizing the capabilities, deriving DOTMLPFI and producing the capability.	11.1	**Quantitative regeneration**	Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor civil "look-alike" products and production lines to military applications.	11.1.1	**Capable of researching and executing strategies that mitigate the need for large numbers of forces**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
12	**Three Domains of War: Physical, Mental and Moral**	Kinetic activity associated with traditional military operations has been joined by actions in the moral and mental (information) domains as equal components of a success campaign plan. The war of ideas, hearts and minds, fourth generation, amongst the people has stressed the relevance of the moral and mental domains. As asymmetric adversaries avoid exposing themselves to the superior conventional force of the Alliance, the importance of actions outside the physical domain become more obvious. Within irregular warfare the importance of the moral domain becomes dominant as the security of the people becomes an overarching goal. In the future, physical actions will be used to enable the achievement of objectives in the mental and moral domains.	12.1	**Need to develop capabilities that act in the information and moral domain**	The character of war is expanding from just traditional force-on-force engagements to more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to 'win the peace' must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations. This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain.	12.1.5	**Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment**
			12.2	**Cyber security**	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	12.2.6	**Capable of acting without access to cyberspace**

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Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
13	**Coalition Operations**	In the future, no single instrument of power will be able to solve complex crises. Coalitions will be used extensively to conduct all manner of military operations. Members of the coalition will provide various capabilities to the force while accepting differing levels of risk. Coalition operations will highlight areas such as interoperability and common doctrine. The ability to develop a common strategy within a common legal framework will be crucial to the achievement of coalition objectives. This Theme raises issue of interoperability, role specialization, training and sharing of technology.	13.1	**Burden sharing**	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	13.1.2	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**
			13.2	**Legal issues and caveats**	Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.	13.2.3	**Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
14	**Space is Opening Up**	By 2030 the amount of traffic in space will have increased markedly requiring coordination and regulation. The Alliance will remain dominant in this area with capabilities for ISR, navigation and weather observation based in space. The commercial sector of particularly Western economies also relies heavily on space communications. The reliance of the Alliance on space could develop into a focus area for possible adversaries that could seek to exploit this potential 'Achilles Heel'. Space junk and anti-satellite systems are threats to the usage of space during operations. Commercial enterprises have built to allow even small groups to have access to space imagery that could be used for intelligence purposes. Space situational awareness becomes an important component for future Alliance operations.	14.1	**Critical dependence upon space assets**	The dependence on space assets, for example, communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	14.1.2	**Capable of acting without access to space assets**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
16	**Political Transformation**	Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require: the capability to arrive at political decisions in a timely manner; the need to share equitably the burden of risk and cost; the incorporation of the 'whole-of-government' or 'comprehensive' approach; and the need to garner public support for ongoing operations.	16.1	**Achieving campaign level surprise**	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	16.1.5	**Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour**
						16.1.7	**Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa**
			16.2	**Burden sharing**	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	16.2.2	**Capable of measuring, analysing, predicting and anticipating risk within a complex environment**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
16	**Political Transformation**	Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require: the capability to arrive at political decisions in a timely manner; the need to share equitably the burden of risk and cost; the incorporation of the 'whole-of-government' or 'comprehensive' approach; and the need to garner public support for ongoing operations.	16.3	**Comprehensive approach**	Embedding military capability/efforts in inter-agency endeavours.	16.3.1	**Capable of conducting civil-military cooperation in an inter-agency environment**
						16.3.3	**Capable of formulating and executing shared and realistic actions**
						16.3.4	**Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements**
						16.3.7	**Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour**
						16.3.8	**Capable of undertaking in-depth foresight analysis to develop models of the future security environment**

Theme No	Theme	Theme Summary	Issue No	Issue	Issue Description	Cap Req No	Capability Requirement
17	**The Role of Information and the Media**	The media has become instrumental in developing the context for the public audiences that affect the Alliance. The pervasive 24/7 media cycle will continue to create the 'CNN effect' where strong emotional content can engender public reaction which may affect political and military decision-making at all levels of command. There is a symbiotic relationship between the military and the media in that the media requires access and information and the military needs the media to communicate with the public. The increased instantaneous access to information available to the public will be a serious consideration in the future as public perception can drive constraints on both the political and military levels.	17.1	**24-hour media cycle**	The Alliance will work in an environment where the news media will be pervasive and will have access to (near) real-time transmission capabilities to a global audience. This could harm military operations. Or is this something that the military can try to influence or take advantage of? The speed with which media can report on incidents during operations far exceeds ability of Commanders to present a comprehensive insight into the NATO 'side of the story'. This can most certainly result in incorrect, possibly volatile, information being spread through a theatre of operations bring about serious consequences.	17.1.3	**Capable of designing effective media strategies**
			17.3	**Media as an intelligence source for the enemy**	The proliferation of media and mediums through which information related to operations can be accessed has significantly increased the use of media reports as sources for intelligence. Adversaries have used traditional media reports, as well as more non-traditional sources such as YouTube and Google, to access geographic data and receive results of attacks and assessments of the quality of tactics. Ambient intelligence?	17.3.2	**Capable of exploiting information space for disinforming opponents**

Annex D – THE JOINT OPERATIONS 2030 CAPABILITY SET

The following table contains the 355 Theme-Issue-Capability combinations that were generated in Phase III of the SAS-066 JO 2030 Study and constitute the Joint Operations 2030 Capability Set.

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.1.1	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.	Capable of 'Sense and Respond'
1.1.2	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.	Capable of generating coherent and integrated policy options
1.1.3	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.1.3	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily. (cont'd)	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
1.1.4	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
1.1.5	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
1.1.6	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.	Capable of shaping the 'home front' in the grey zone between peace and conflict

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.1.7	Blurred Distinction between Peace and Conflict	Peace and conflict coexist	In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.	Capable of finding other actors and contracting/influencing/persuading them to shape the environment
1.2.1	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a "complex system"	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a "complex system" with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of 'Sense and Respond'
1.2.2	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a "complex system"	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a "complex system" with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.2.3	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a “complex system”	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a “complex system” with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
1.2.4	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a “complex system”	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a “complex system” with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
1.2.5	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a “complex system”	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a “complex system” with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.2.6	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a “complex system”	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a “complex system” with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of advanced distributed learning, training/exercises in a multi-level security environment through a single, comprehensive network architecture
1.2.7	Blurred Distinction between Peace and Conflict	Geopolitical security environment as a “complex system”	Countries (and the public) have a difficult time understanding world situations that are critical in nature (high risk) vs. situations that are not or less critical (low risk). There can be a peaceful situation that is on the path to major confrontation and war if action is not taken. Some (potential) conflicts have limited impact on the vital interests of NATO and Member States. However, the geopolitical security environment is a “complex system” with (unpredictable) risks of escalation from small causes to catastrophic consequences. Agile sense, communicating (getting the message out to politicians and public), pro-action and response functions at the strategic level are required.	Capable of rapid strategic reaction to (potentially) major and/or catastrophic crises
1.3.1	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties (see Theme 2, Standing Arrangements). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State).	Capable of ‘Sense and Respond’

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.3.1	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders). (cont'd)	Capable of 'Sense and Respond'
1.3.2	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties (see Theme 2, Standing Arrangements). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders).	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
1.3.3	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties (see Theme 2, Standing Arrangements). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders).	Capable of generating coherent and integrated policy options

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.3.4	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties (see Theme 2, Standing Arrangements). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders).	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
1.3.5	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties (see Theme 2, Standing Arrangements). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders).	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
1.3.6	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties (see Theme 2, Standing Arrangements). In various forms of partnerships or customer-contractor relationships.	Capable of inter agency generic training as well as specific mission rehearsal

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.3.6	Blurred Distinction between Peace and Conflict	Establish a workable division of labour / collaboration structure with other agencies	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders). (cont'd)	Capable of inter agency generic training as well as specific mission rehearsal
1.4.1	Blurred Distinction between Peace and Conflict	Refection of the broad(ened) spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
1.4.2	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
1.4.3	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.4.3	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc. (cont'd)	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
1.4.4	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of conducting civil-military cooperation in an inter-agency environment
1.4.5	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of enhancing the Situational Awareness (SA) of individual soldiers and increasing shared knowledge
1.4.6	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of subduing, dispersing, or controlling individuals or groups of individuals and engaging vehicles/ assets/platforms/systems with a significantly reduced risk of death or permanent injury/damage

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
1.4.7	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of providing identification, location, status and movement of friendly and neutral force elements
1.4.8	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of advanced distributed learning, training/exercises in a multi-level security environment through a single, comprehensive network architecture
1.4.9	Blurred Distinction between Peace and Conflict	Refection of the broad spectrum in Armed Forces concepts, organisation, processes	There is a distinct difference between the core capabilities needed for war fighting (direct action) and (military) tasks in non-violent situations. There is a never ending discussion as to whether the same personnel (and, to a lesser extent, other means and ways) can be used in both capacities. The broadening of the spectrum calls for a review and possibly a redesign of concepts, organisation and processes. Issues that arise include growing urbanization, military vs. police, public vs. private, international vs. internal, etc.	Capable of assessing one's own organisational strengths and weaknesses vis-à-vis those of other parties
2.1.1	Standing Arrangements	Understanding different business models	The real cost/benefit balance between contracting out a service vs. retaining in-house capability is difficult to measure and assess. It is a dynamic balance, to a large extent, driven by actual developments that are difficult to predict in advance.	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
2.1.2	Standing Arrangements	Understanding different business models	The real cost/benefit balance between contracting out a service vs. retaining in-house capability is difficult to measure and assess. It is a dynamic balance, to a large extent, driven by actual developments that are difficult to predict in advance.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
2.1.3	Standing Arrangements	Understanding different business models	The real cost/benefit balance between contracting out a service vs. retaining in-house capability is difficult to measure and assess. It is a dynamic balance, to a large extent, driven by actual developments that are difficult to predict in advance.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
2.1.4	Standing Arrangements	Understanding different business models	The real cost/benefit balance between contracting out a service vs. retaining in-house capability is difficult to measure and assess. It is a dynamic balance, to a large extent, driven by actual developments that are difficult to predict in advance.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
2.2.1	Standing Arrangements	Legal status of service providers	The legal status of contractors that provide a function within an operational theatre must be addressed within international law as they apply to Laws of Armed Conflict and within Status of Forces Agreements with host Nation /local governments. This is particularly the case for combat support (intelligence, communications, etc.) and actual combat functions: both in defence (e.g., guarding facilities, VIPs and convoys) and offence and is driven by both outsourcing and non-contiguous battlefields with no real rear areas.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
2.3.1	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
2.3.2	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of generating coherent and integrated policy options
2.3.3	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
2.3.4	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of 'Sense and Respond'
2.3.5	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
2.3.6	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
2.3.6	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour. (cont'd)	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
2.3.7	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of advanced distributed learning, training/exercises in a multi-level security environment through a single, comprehensive network architecture
2.3.8	Standing Arrangements	Establish a workable division of labour / collaboration structure with external service providers	Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties and reflecting a variety of different customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.	Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations
3.1.1	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
3.1.2	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of advanced distributed learning, training/exercises in a multi-level security environment through a single, comprehensive network architecture

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
3.1.3	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
3.1.4	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
3.1.5	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
3.1.6	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
3.1.7	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of providing a Networking and Information Infrastructure (NII) to enable NATO to conduct future operations
3.1.8	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of developing flexible and adaptive leaders

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
3.1.9	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of preserving space as a sanctuary for NATO assets
3.1.10	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of assessing in near real-time open sources of information for relevant data
3.1.11	Planning Under Deep Uncertainty	Dealing with intrinsic uncertainty	Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues: change the OPP; adaptive leadership Symposium; learning adaptivity; invest in training; lessons learned; and breaking of the control paradigm.	Capable of stimulating, absorbing, exploiting and rewarding diversity in the military, including appropriate training
3.2.1	Planning Under Deep Uncertainty	Financial planning in Government	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. There is a need for better ways of cash managing defence budgets that include hedging strategies to deal with price fluctuations of assets and commodities.	Capable of ‘Sense and Respond’
3.2.2	Planning Under Deep Uncertainty	Financial planning in Government	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. There is a need for better ways of cash managing defence budgets that include hedging strategies to deal with price fluctuations of assets and commodities.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
3.2.3	Planning Under Deep Uncertainty	Financial planning in Government	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. There is a need for better ways of cash managing defence budgets that include hedging strategies to deal with price fluctuations of assets and commodities.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
3.2.4	Planning Under Deep Uncertainty	Financial planning in Government	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. There is a need for better ways of cash managing defence budgets that include hedging strategies to deal with price fluctuations of assets and commodities.	Capable of dynamically managing budgets within a complex environment
3.2.5	Planning Under Deep Uncertainty	Financial planning in Government	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. There is a need for better ways of cash managing defence budgets that include hedging strategies to deal with price fluctuations of assets and commodities.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
3.2.6	Planning Under Deep Uncertainty	Financial planning in Government	Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. There is a need for better ways of cash managing defence budgets that include hedging strategies to deal with price fluctuations of assets and commodities.	Capable of modelling cost of various force structure options
3.3.1	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process. But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement.	Capable of ‘Sense and Respond’
3.3.2	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process. But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
3.3.3	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
3.3.3	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement. (cont’d)	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
3.3.4	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process. But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement.	Capable of dynamically managing budgets within a complex environment
3.3.5	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process. But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
3.3.6	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process. But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement.	Capable of modelling cost of various force structure options
3.3.7	Planning Under Deep Uncertainty	Capability assessment toolsets and processes	Existing capability assessment toolsets determine requirements very specifically and very early in the capability development process. But the future environment in which the capability is deployed is intrinsically unknowable and risks situating the estimate, or limiting operational flexibility and agility. Includes, e.g., ‘smart’ and “fast track’ procurement.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
3.4.1	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
3.4.1	Planning Under Deep Uncertainty	Future structures	Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered. (cont'd)	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
3.4.2	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
3.4.3	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of dynamically managing budgets within a complex environment
3.4.4	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
3.4.5	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of modelling cost of various force structure options
3.4.6	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained.	Capable of 'Sense and Respond'

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
3.4.6	Planning Under Deep Uncertainty	Future structures	Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered. (cont'd)	Capable of 'Sense and Respond'
3.4.7	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
3.4.8	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
3.4.9	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
3.4.10	Planning Under Deep Uncertainty	Future structures	The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world could be examined for applicability: outsourcing of services and the use of market adaptation mechanisms could be considered.	Capable of acting in dynamic 'value chains' with a variety of potential partners
4.1.1	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.1.1	Different Paradigms in Decision-Making	Achieving common objectives	There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation). (cont'd)	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
4.1.2	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
4.1.3	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
4.1.4	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.1.4	Different Paradigms in Decision-Making	Achieving common objectives	There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation). (cont'd)	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
4.1.5	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
4.1.6	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
4.1.7	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult.	Capable to construct a hierarchy or possibly a network of objectives for the various actors from the overarching objective(s) of the comprehensive approach

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.1.7	Different Paradigms in Decision-Making	Achieving common objectives	There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation). (cont'd)	Capable to construct a hierarchy or possibly a network of objectives for the various actors from the overarching objective(s) of the comprehensive approach
4.1.8	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach
4.1.9	Different Paradigms in Decision-Making	Achieving common objectives	The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities that reside in each of the organizations upon achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).	Capable of inter agency generic training as well as specific mission rehearsal
4.2.1	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so.	Capable of controlling/influencing the cyberspace environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.2.1	Different Paradigms in Decision-Making	Information management	In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour. (cont’d)	Capable of controlling/influencing the cyberspace environment
4.2.2	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour.	Capable of providing disruption resistant communications services for the implementation of a Networking and Information Infrastructure (NII)
4.2.3	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour.	Capable of providing Information and Integration Services (IIS) for the implementation of a Networking and Information Infrastructure (NII)
4.2.4	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so.	Capable of providing Information Assurance (IA) services for the implementation of a Networking and Information Infrastructure (NII)

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.2.4	Different Paradigms in Decision-Making	Information management	In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour. (cont’d)	Capable of providing Information Assurance (IA) services for the implementation of a Networking and Information Infrastructure (NII)
4.2.5	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour.	Capable of providing identification, location, status and movement of friendly and neutral force elements
4.2.6	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour.	Capable of providing Service Management and Control (SMC) services for the implementation of a Networking and Information Infrastructure (NII)
4.2.7	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so.	Capable of developing information/ weapons systems with open architectures and common standards that will incorporate legacy systems

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.2.7	Different Paradigms in Decision-Making	Information management	In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour. (cont’d)	Capable of developing information/ weapons systems with open architectures and common standards that will incorporate legacy systems
4.2.8	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour.	Capable of incorporating artificial intelligence into systems to speed fusion of information and decision-making
4.2.9	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour.	Capable of digesting lessons identified into lessons learned and anchoring this in the organisation (organisation learning)
4.2.10	Different Paradigms in Decision-Making	Information management	The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so.	Capable of acting in dynamic ‘value chains’ with a variety of potential partners

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.2.10	Different Paradigms in Decision-Making	Information management	In general, in a NEC environment, the traditional ‘top-down’ stream of information is augmented by a structural ‘bottom-up’ stream as well as a ‘sideways’ stream to Allies and ‘other’ agencies involved in the endeavour. (cont’d)	Capable of acting in dynamic ‘value chains’ with a variety of potential partners
4.3.1	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of developing flexible and adaptive leaders
4.3.2	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
4.3.3	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
4.3.4	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
4.3.5	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of employing lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
4.3.6	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of employing non or less lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage
4.3.7	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of rapidly deploying significant military forces into and within a theatre of operations to enable swift crisis resolution
4.3.8	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of providing real-time audio and textual language translation to overcome language and communication barriers
4.3.9	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of increased self-sustainment for units deployed in theatre by effectively exploiting available resources
4.3.10	Different Paradigms in Decision-Making	Complex adaptive adversaries	In NATO operations, adversaries will continue to use highly complex adaptive systems that react and learn from encounters with Alliance forces and use decentralized structures that are difficult to discern to pass information and tactics, techniques and procedures throughout the network (linear vs. non-linear decision-making).	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
5.1.1	Evolving Relationships between Man, Robotics and Machine Intelligence	Moral, ethical and legal considerations of “human-out-of-the-loop”	With the human out of the loop or not “at risk”, the parameters for deciding on whether, where, when and how to wage war shift, at the political, strategically and operational/tactical level. What are the bounds/benefits of “automation” of military tasks? Winning the hearts and minds vs. safety of troops.	Capable of analysing vast amount of code to ensure that ‘bugs’ are truly limited so as to allow great machine automation of process that require extremely fast decision-making

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
5.1.1	Evolving Relationships between Man, Robotics and Machine Intelligence	Moral, ethical and legal considerations of "human-out-of-the-loop"	Unmanned systems are typically used in dull, dirty or dangerous environments/tasks. Psychological/moral aspect – is the potential for escalation higher if technology substitutes personnel? (cont'd)	Capable of analysing vast amount of code to ensure that 'bugs' are truly limited so as to allow great machine automation of process that require extremely fast decision-making
5.1.2	Evolving Relationships between Man, Robotics and Machine Intelligence	Moral, ethical and legal considerations of "human-out-of-the-loop"	With the human out of the loop or not "at risk", the parameters for deciding on whether, where, when and how to wage war shift, at the political, strategically and operational/tactical level. What are the bounds/benefits of "automation" of military tasks? Winning the hearts and minds vs. safety of troops. Unmanned systems are typically used in dull, dirty or dangerous environments/tasks. Psychological/moral aspect – is the potential for escalation higher if technology substitutes personnel?	Capable of tracing / back tracking all fires
5.1.3	Evolving Relationships between Man, Robotics and Machine Intelligence	Moral, ethical and legal considerations of "human-out-of-the-loop"	With the human out of the loop or not "at risk", the parameters for deciding on whether, where, when and how to wage war shift, at the political, strategically and operational/tactical level. What are the bounds/benefits of "automation" of military tasks? Winning the hearts and minds vs. safety of troops. Unmanned systems are typically used in dull, dirty or dangerous environments/tasks. Psychological/moral aspect – is the potential for escalation higher if technology substitutes personnel?	Capable of defining unambiguous Rules Of Engagement (ROEs)
5.1.4	Evolving Relationships between Man, Robotics and Machine Intelligence	Moral, ethical and legal considerations of "human-out-of-the-loop"	With the human out of the loop or not "at risk", the parameters for deciding on whether, where, when and how to wage war shift, at the political, strategically and operational/tactical level. What are the bounds/benefits of "automation" of military tasks? Winning the hearts and minds vs. safety of troops. Unmanned systems are typically used in dull, dirty or dangerous environments/tasks. Psychological/moral aspect – is the potential for escalation higher if technology substitutes personnel?	Capable of flawless IFF and flawless autonomous targeting
5.2.1	Evolving Relationships between Man, Robotics and Machine Intelligence	Speed of action and reaction (trans-human capacity)	With an increasing operational tempo because of technological advance, is the human-in-the-loop more and more the bottleneck for timely action and situation-specific adaptation? What does this mean for the role of humans in military operations?	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
5.2.2	Evolving Relationships between Man, Robotics and Machine Intelligence	Speed of action and reaction (trans-human capacity)	With an increasing operational tempo because of technological advance, is the human-in-the-loop more and more the bottleneck for timely action and situation-specific adaptation? What does this mean for the role of humans in military operations?	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
5.2.3	Evolving Relationships between Man, Robotics and Machine Intelligence	Speed of action and reaction (trans-human capacity)	With an increasing operational tempo because of technological advance, is the human-in-the-loop more and more the bottleneck for timely action and situation-specific adaptation? What does this mean for the role of humans in military operations?	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
5.2.4	Evolving Relationships between Man, Robotics and Machine Intelligence	Speed of action and reaction (trans-human capacity)	With an increasing operational tempo because of technological advance, is the human-in-the-loop more and more the bottleneck for timely action and situation-specific adaptation? What does this mean for the role of humans in military operations?	Capable of incorporating artificial intelligence into systems to speed fusion of information and decision-making
5.3.1	Evolving Relationships between Man, Robotics and Machine Intelligence	Other system life cycles	If system performance is largely determined by software, system upgrade/adaptation becomes largely a matter of changing software modules – distributed, online and real-time. This applies also to decision algorithms, codifying doctrine and rules of engagements.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
5.4.1	Evolving Relationships between Man, Robotics and Machine Intelligence	Bio-mechanical enhancements to humans that increase capabilities and capacity	Increased human performance by (literally) integrating technology into humans (as opposed to replacing humans by technology). Think of, brain-machine interfaces, bionics, brain stimulating drugs, etc.	Capable of increasing the performance and endurance of personnel on deployed operations
5.4.2	Evolving Relationships between Man, Robotics and Machine Intelligence	Bio-mechanical enhancements to humans that increase capabilities and capacity	Increased human performance by (literally) integrating technology into humans (as opposed to replacing humans by technology). Think of, brain-machine interfaces, bionics, brain stimulating drugs, etc.	Capable of dealing with the ethical/ judicial issues
6.1.1	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of countering mobile underwater threats, including sub-surface vehicles, swimmers and torpedoes

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
6.1.2	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of detecting and successfully engaging low signature airborne targets
6.1.3	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of effectively countering threats to low speed / low altitude air vehicles
6.1.4	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of detection, warning and neutralization of full spectrum of CBRN agents or contaminants and identifying the type of agent or contaminant and the area affected
6.1.5	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of intercepting and destroying in-flight ballistic missiles
6.1.6	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of selectively denying the use of the EM spectrum to opponents without impacting its use by NATO
6.1.7	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
6.1.8	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of providing integrated personal protection from the range of threats faced in operational theatres (ballistics, Chemical, Biological, Radiological and Nuclear (CBRN), environmental, etc.)

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
6.1.9	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of increasing the performance and endurance of personnel on deployed operations
6.1.10	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of enhancing the mobility and survivability of (predominantly but not exclusively land) vehicles on deployed operations
6.1.11	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
6.1.12	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of establishing forward air and seaports of disembarkation
6.1.13	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of detecting and neutralising 'internal' threats (within/under the security umbrella)
6.1.14	Staying Power	Provide a sustained security umbrella at relatively low, manageable costs	Typically in prolonged stabilisation and reconstruction endeavours. Includes practical solutions such as leaving equipment behind, and shared use of resources and capabilities from cycle to cycle of an operation.	Capable of automatic/self repair
6.2.1	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of controlling/influencing the cyberspace environment
6.2.2	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of defeating incoming rocket, artillery and mortar rounds

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
6.2.3	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of countering IED threats at any point in the life cycle
6.2.4	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of remote/immediate medical assessment and first aid to ensure that battlefield casualties receive appropriate medical treatment within appropriate medical timelines
6.2.5	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of controlling access to designated unattended areas and borders using lethal/non-lethal means, denying or allowing access to those appropriate personnel and equipment
6.2.6	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
6.2.7	Staying Power	Facilitate political stamina	Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.	Capable of modelling cost of various force structure options
6.3.1	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the 'civ-mil loop' implied here goes beyond what is currently understood under the term 'CIMIC' (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not 'owned' by the military.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
6.3.2	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the ‘civ-mil loop’ implied here goes beyond what is currently understood under the term ‘CIMIC’ (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not ‘owned’ by the military.	Capable of developing and assessing standardised business rules and practices among military, industry, NGO, IO and other entities
6.3.3	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the ‘civ-mil loop’ implied here goes beyond what is currently understood under the term ‘CIMIC’ (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not ‘owned’ by the military.	Capable of conducting civil-military cooperation in an inter-agency environment
6.3.4	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the ‘civ-mil loop’ implied here goes beyond what is currently understood under the term ‘CIMIC’ (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not ‘owned’ by the military.	Capable of providing identification, location, status and movement of friendly and neutral force elements
6.3.5	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours.	Capable of developing flexible and adaptive leaders

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
6.3.5	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	It should be noted that the 'civ-mil loop' implied here goes beyond what is currently understood under the term 'CIMIC' (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not 'owned' by the military. (cont'd)	Capable of developing flexible and adaptive leaders
6.3.6	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the 'civ-mil loop' implied here goes beyond what is currently understood under the term 'CIMIC' (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not 'owned' by the military.	Capable of dynamically managing budgets within a complex environment
6.3.7	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the 'civ-mil loop' implied here goes beyond what is currently understood under the term 'CIMIC' (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not 'owned' by the military.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
6.3.8	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours. It should be noted that the 'civ-mil loop' implied here goes beyond what is currently understood under the term 'CIMIC' (Civil-Military Cooperation).	Capable of modelling cost of various force structure options

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
6.3.8	Staying Power	Establish a workable division of labour / collaboration structure with other agencies	CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civ-mil interaction here is aimed at achieving a higher order objective and is not 'owned' by the military. (cont'd)	Capable of modelling cost of various force structure options
7.1.1	Small Team Operations	Self awareness	Know your own strength and weaknesses in response to external circumstances, both in a general sense (for planning purposes) as well as in a particular situation (for measured action).	Capable of enhancing the Situational Awareness (SA) of individual soldiers and increasing shared knowledge
7.1.2	Small Team Operations	Self awareness	Know your own strength and weaknesses in response to external circumstances, both in a general sense (for planning purposes) as well as in a particular situation (for measured action).	Capable of providing identification, location, status and movement of friendly and neutral force elements
7.1.3	Small Team Operations	Self awareness	Know your own strength and weaknesses in response to external circumstances, both in a general sense (for planning purposes) as well as in a particular situation (for measured action).	Capable of providing a Networking and Information Infrastructure (NII) to enable NATO to conduct future operations
7.1.4	Small Team Operations	Self awareness	Know your own strength and weaknesses in response to external circumstances, both in a general sense (for planning purposes) as well as in a particular situation (for measured action).	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
7.1.5	Small Team Operations	Self awareness	Know your own strength and weaknesses in response to external circumstances, both in a general sense (for planning purposes) as well as in a particular situation (for measured action).	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
7.2.1	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
7.2.2	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
7.2.3	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of enhanced, effective, and flexible beyond line-of-sight communication
7.2.4	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of providing integrated personal protection from the range of threats faced in operational theatres (ballistics, Chemical, Biological, Radiological and Nuclear (CBRN), environmental, etc.)
7.2.5	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of increased self-sustainment for units deployed in theatre by effectively exploiting available resources
7.2.6	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of the covert deployment, extraction and resupply of forces (company size and larger, i.e., not only Special Forces) into areas of the operational theatre not controlled by own forces and located a significant distance away from the normal supply chain, whether on land or sea
7.2.7	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an "effects-based" feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of tagging and tracking individuals or vehicles

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
7.2.8	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of controlling access to designated unattended areas and borders using lethal/non-lethal means, denying or allowing access to those appropriate personnel and equipment
7.2.9	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of employing lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage
7.2.10	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of employing non or less lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage
7.2.11	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of countering IED threats at any point in the life cycle
7.2.12	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of defeating incoming rocket, artillery and mortar rounds
7.2.13	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of countering static underwater threats, including detecting and disposing of all types of naval mines in all water bodies and at all water depths
7.2.14	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of ‘seeing through walls’ to facilitate urban operations
7.2.15	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of subduing, dispersing, or controlling individuals or groups of individuals and engaging vehicles/ assets/platforms/systems with a significantly reduced risk of death or permanent injury/damage

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
7.2.16	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of employing scalable weapons that can be designated depended on the circumstances
7.2.17	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of developing power systems appropriate for the energy requirements of personnel systems
7.2.18	Small Team Operations	Local sense and respond	Situation specific actions, possibly in a smart trial-and-error mode with an “effects-based” feedback loop. Flexible doctrine and emergent strategies based on experienced successes and failures.	Capable of developing innovative camouflage, concealment and deception
7.3.1	Small Team Operations	Quick organisational learning cycle	Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen emergent strategies that have been tested and proven ineffective and to amplify those emergent strategies that have been shown to be effective. Sharing of ‘situational understanding’ to achieve coherent effects that are realistic in the given situation.	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
7.3.2	Small Team Operations	Quick organisational learning cycle	Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen emergent strategies that have been tested and proven ineffective and to amplify those emergent strategies that have been shown to be effective. Sharing of ‘situational understanding’ to achieve coherent effects that are realistic in the given situation.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
7.3.3	Small Team Operations	Quick organisational learning cycle	Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen emergent strategies that have been tested and proven ineffective and to amplify those emergent strategies that have been shown to be effective. Sharing of ‘situational understanding’ to achieve coherent effects that are realistic in the given situation.	Capable of gathering, analysing and disseminating lessons learned in a timely fashion
7.3.4	Small Team Operations	Quick organisational learning cycle	Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen emergent strategies that have been tested and proven ineffective and to amplify those emergent strategies that have been shown to be effective. Sharing of ‘situational understanding’ to achieve coherent effects that are realistic in the given situation.	Capable of adapting organizational structures to reflect changing circumstances and evolving objectives

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
7.4.1	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of increasing the performance and endurance of personnel on deployed operations
7.4.2	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of providing integrated personal protection from the range of threats faced in operational theatres (ballistics, Chemical, Biological, Radiological and Nuclear (CBRN), environmental, etc.)
7.4.3	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of ready deployment, high mobility, high-tempo manoeuvre dominance operations, and survivable land engagement
7.4.4	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of providing real-time audio and textual language translation to overcome language and communication barriers
7.4.5	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of subduing, dispersing, or controlling individuals or groups of individuals and engaging vehicles/ assets/platforms/systems with a significantly reduced risk of death or permanent injury/damage
7.4.6	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of providing identification, location, status and movement of friendly and neutral force elements
7.4.7	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of enhancing the Situational Awareness (SA) of individual soldiers and increasing shared knowledge

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
7.4.8	Small Team Operations	Develop individual skill sets, and combine those skill sets into effective teams	Selection, education and training system geared towards personal professionalization. Training, operational planning and actual operations geared towards effective team composition and performance.	Capable of remote/immediate medical assessment and first aid to ensure that battlefield casualties receive appropriate medical treatment within appropriate medical timelines
7.5.1	Small Team Operations	Endeavour specific training	Situation-specific training to be adaptive, loose and late coupling of individual resources (people, means and ways) to effective, internally coherent teams. Emergent leadership based upon individual skill sets and the endeavour specific tasks and circumstances.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
7.5.2	Small Team Operations	Endeavour specific training	Situation-specific training to be adaptive, loose and late coupling of individual resources (people, means and ways) to effective, internally coherent teams. Emergent leadership based upon individual skill sets and the endeavour specific tasks and circumstances.	Capable of developing flexible and adaptive leaders
8.1.1	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of developing flexible and adaptive leaders
8.1.2	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of gathering, analysing and disseminating lessons learned in a timely fashion

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
8.1.3	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
8.1.4	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
8.1.5	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
8.1.6	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations).	Capable of measuring, analysing, predicting and anticipating risk within a complex environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
8.1.6	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue? (cont'd)	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
8.1.7	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of modelling cost of various force structure options
8.1.8	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of conducting civil-military cooperation in an inter-agency environment
8.1.9	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
8.1.9	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue? (cont'd)	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
8.1.10	Strategic Compression	Different causal relationships across the levels of conflict/ organisations/endeavours	Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How does accountability and media coverage/pressure affect the issue?	Capable of managing and exploiting information flowing top-down, bottom-up and sideways in a multi-agency environment
8.2.1	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of controlling/influencing the cyberspace environment
8.2.2	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of providing a Networking and Information Infrastructure (NII) to enable NATO to conduct future operations
8.2.3	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of providing identification, location, status and movement of friendly and neutral force elements

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
8.2.4	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
8.2.5	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of assessing in near real-time open sources of information for relevant data
8.2.6	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of developing information/ weapons systems with open architectures and common standards that will incorporate legacy systems
8.2.7	Strategic Compression	Information management	Conventional quality reportage, objective coverage, sources of information validation loose their bearings under strategic compression. These information processes and products are partly replaced by raw, unprocessed, unregulated, or even manipulated sources and streams of information, directly available to the actors at the various levels, and to the public.	Capable of swiftly assessing media information and responding with truth data
8.3.1	Strategic Compression	Morality and culture in coalition / inter-agency endeavours	If typical operations become more international and inter-agency (and even with external service providers), with (the need for) cooperation and collaboration pushing down to the tactical level (see, e.g., small team operations), several issues arise. The most fundamental issue might be the need to make an endeavour succeed with parties that act from quite diverse moral and cultural views.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
9.1.1	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
9.1.2	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
9.1.3	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
9.1.3	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge. (cont'd)	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
9.1.4	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of modelling cost of various force structure options
9.1.5	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of controlling/influencing the cyberspace environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
9.1.6	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of the covert deployment, extraction and resupply of forces (company size and larger, i.e., not only Special Forces) into areas of the operational theatre not controlled by own forces and located a significant distance away from the normal supply chain, whether on land or sea
9.1.7	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of detection, warning and neutralization of full spectrum of CBRN agents or contaminants and identifying the type of agent or contaminant and the area affected
9.1.8	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
9.1.8	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge. (cont'd)	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
9.1.9	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
9.1.10	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
9.1.11	Dual-Use Technologies	Spin-in of high quality, high pace innovation	Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be incorporated effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.	Capable of fast technology insertion
9.2.1	Dual-Use Technologies	Pace of technology development	The pace of technology development is accelerating with a big jump ahead through the combination of advances in ICT, nano and bio technology and cognitive sciences. The variety of ways to wage war may drastically increase – faster than society can keep up in terms of legal and moral embedding of the phenomenon of war.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
9.2.2	Dual-Use Technologies	Pace of technology development	The pace of technology development is accelerating with a big jump ahead through the combination of advances in ICT, nano and bio technology and cognitive sciences. The variety of ways to wage war may drastically increase – faster than society can keep up in terms of legal and moral embedding of the phenomenon of war.	Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology
9.2.3	Dual-Use Technologies	Pace of technology development	The pace of technology development is accelerating with a big jump ahead through the combination of advances in ICT, nano and bio technology and cognitive sciences. The variety of ways to wage war may drastically increase – faster than society can keep up in terms of legal and moral embedding of the phenomenon of war.	Capable of enforcing restrictions on civilian technologies with military applications
9.3.1	Dual-Use Technologies	Disruptive technologies	Globalisation and “civilisation” of military technology make proliferation control a rearguard battle. Adversaries might come up with technology applications that suddenly tip the military balance (e.g., between the offensive and the defence), rendering Western military superiority (locally and temporarily) useless.	Capable of monitoring emerging and developing technology in the commercial and defence sectors

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
9.3.2	Dual-Use Technologies	Disruptive technologies	Globalisation and “civilisation” of military technology make proliferation control a rearguard battle. Adversaries might come up with technology applications that suddenly tip the military balance (e.g., between the offensive and the defence), rendering Western military superiority (locally and temporarily) useless.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
9.3.3	Dual-Use Technologies	Disruptive technologies	Globalisation and “civilisation” of military technology make proliferation control a rearguard battle. Adversaries might come up with technology applications that suddenly tip the military balance (e.g., between the offensive and the defence), rendering Western military superiority (locally and temporarily) useless.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
9.3.4	Dual-Use Technologies	Disruptive technologies	Globalisation and “civilisation” of military technology make proliferation control a rearguard battle. Adversaries might come up with technology applications that suddenly tip the military balance (e.g., between the offensive and the defence), rendering Western military superiority (locally and temporarily) useless.	Capable of fast technology insertion
10.1.1	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
10.1.2	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of ‘Sense and Respond’

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.1.3	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
10.1.4	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
10.1.5	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
10.1.6	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.1.6	Non-Military/ Non-Violent Threats	Expansion of the mission set	How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain? (cont'd)	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
10.1.7	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
10.1.8	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of controlling/influencing the cyberspace environment
10.1.9	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of subduing, dispersing, or controlling individuals or groups of individuals and engaging vehicles/ assets/platforms/systems with a significantly reduced risk of death or permanent injury/damage

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.1.10	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of real-time medical surveillance of populations
10.1.11	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of gathering meteorological information and providing accurate forecasts of future environmental conditions
10.1.12	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate. How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?	Capable of controlling access to designated unattended areas and borders using lethal/non-lethal means, denying or allowing access to those appropriate personnel and equipment
10.1.13	Non-Military/ Non-Violent Threats	Expansion of the mission set	Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate.	Capable of digesting lessons identified into lessons learned and anchoring this in the organisation (organisation learning)

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.1.13	Non-Military/ Non-Violent Threats	Expansion of the mission set	How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain? (cont'd)	Capable of digesting lessons identified into lessons learned and anchoring this in the organisation (organisation learning)
10.2.1	Non-Military/ Non-Violent Threats	Risk prioritisation, balance of investments and scaling problem	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There's a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
10.2.2	Non-Military/ Non-Violent Threats	Risk prioritisation, balance of investments and scaling problem	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There's a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
10.2.3	Non-Military/ Non-Violent Threats	Risk prioritisation, balance of investments and scaling problem	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There's a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	Capable of generating coherent and integrated policy options

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.2.4	Non-Military/ Non-Violent Threats	Risk prioritisation, balance of investments and scaling problem	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There’s a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	Capable of modelling cost of various force structure options
10.2.5	Non-Military/ Non-Violent Threats	Risk prioritisation, balance of investments and scaling problem	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There’s a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	Capable of swiftly assessing and developing antidotes, vaccines, treatments or decontamination against all agents
10.2.6	Non-Military/ Non-Violent Threats	Risk prioritisation, balance of investments and scaling problem	Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that? For non-traditional threats there will be a (initial?) lack of threat predictability. There’s a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.	Capable of gathering, analysing and disseminating lessons learned in a timely fashion

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.3.1	Non-Military/ Non-Violent Threats	Legal embedding	Legal considerations for the employment of military forces in non-military endeavours, both nationally and (particularly) across borders.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
10.3.2	Non-Military/ Non-Violent Threats	Legal embedding	Legal considerations for the employment of military forces in non-military endeavours, both nationally and (particularly) across borders.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
10.4.1	Non-Military/ Non-Violent Threats	Establish a workable division of labour / collaboration structure with other agencies	Efficient responses will need to combine the actions of many different actors to achieve the overall effect. Includes avoiding duplication with other actors (NGOs, PVOs, economists, politicians, etc.). This comprehensive approach may have to include people who and institutions that don’t want to be coordinated.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
10.4.2	Non-Military/ Non-Violent Threats	Establish a workable division of labour / collaboration structure with other agencies	Efficient responses will need to combine the actions of many different actors to achieve the overall effect. Includes avoiding duplication with other actors (NGOs, PVOs, economists, politicians, etc.). This comprehensive approach may have to include people who and institutions that don’t want to be coordinated.	Capable of generating coherent and integrated policy options
10.4.3	Non-Military/ Non-Violent Threats	Establish a workable division of labour / collaboration structure with other agencies	Efficient responses will need to combine the actions of many different actors to achieve the overall effect. Includes avoiding duplication with other actors (NGOs, PVOs, economists, politicians, etc.). This comprehensive approach may have to include people who and institutions that don’t want to be coordinated.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
10.4.4	Non-Military/ Non-Violent Threats	Establish a workable division of labour / collaboration structure with other agencies	Efficient responses will need to combine the actions of many different actors to achieve the overall effect. Includes avoiding duplication with other actors (NGOs, PVOs, economists, politicians, etc.). This comprehensive approach may have to include people who and institutions that don’t want to be coordinated.	Capable of ‘Sense and Respond’

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
10.4.5	Non-Military/ Non-Violent Threats	Establish a workable division of labour / collaboration structure with other agencies	Efficient responses will need to combine the actions of many different actors to achieve the overall effect. Includes avoiding duplication with other actors (NGOs, PVOs, economists, politicians, etc.). This comprehensive approach may have to include people who and institutions that don't want to be coordinated.	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment
11.1.1	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial "look-alike" products and production lines to military applications.	Capable of researching and executing strategies that mitigate the need for large numbers of forces
11.1.2	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial "look-alike" products and production lines to military applications.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
11.1.3	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial "look-alike" products and production lines to military applications.	Capable of modelling cost of various force structure options
11.1.4	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial "look-alike" products and production lines to military applications.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
11.1.5	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way.	Capable of developing and executing recruitment strategies

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
11.1.5	Regeneration	Quantitative regeneration	A crucial element might be agreements with dual-use industry to rapidly tailor commercial “look-alike” products and production lines to military applications. (cont’d)	Capable of developing and executing recruitment strategies
11.1.6	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability “in numbers”, and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial “look-alike” products and production lines to military applications.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
11.1.7	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability “in numbers”, and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial “look-alike” products and production lines to military applications.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
11.1.8	Regeneration	Quantitative regeneration	Ability to timely regenerate a down scaled capability “in numbers”, and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor commercial “look-alike” products and production lines to military applications.	Capable of replacing people with technology
11.2.1	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
11.2.2	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of researching and executing asymmetric strategies that mitigate the need for large numbers of forces
11.2.3	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
11.2.4	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of modelling cost of various force structure options
11.2.5	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
11.2.5	Regeneration	Qualitative regeneration	A crucial element is the ability to routinely and effectively preserve knowledge within the military. (cont'd)	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
11.2.6	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
11.2.7	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
11.2.8	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of digesting lessons identified into lessons learned and anchoring this in the organisation (organisation learning)

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
11.2.9	Regeneration	Qualitative regeneration	Ability to timely regenerate a phased-out capability to meet a (re-)emerging threat. Regeneration is an option that may compete with or is complementary to building new capabilities (and thus an instrument in an adaptive and robust organisation/strategy). Regeneration may apply to a complete capability or to, e.g., a discarded doctrine that may be re-applied (with current means) to deal with a re-emerging threat. A crucial element is the ability to routinely and effectively preserve knowledge within the military.	Capable of advanced distributed learning, training / exercises in a multi-level security environment through a single, comprehensive network architecture
12.1.1	Three Domains of War: Physical, Mental and Moral	Need to develop capabilities that act in the information and moral domain	The character of war is expanding from just traditional force-on-force engagements to include more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to 'win the peace' must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations. This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain.	Capable of swiftly assessing media information and responding with truth data
12.1.2	Three Domains of War: Physical, Mental and Moral	Need to develop capabilities that act in the information and moral domain	The character of war is expanding from just traditional force-on-force engagements to include more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to 'win the peace' must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations. This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain.	Capable of assessing in near real-time open sources of information for relevant data

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
12.1.3	Three Domains of War: Physical, Mental and Moral	Need to develop capabilities that act in the information and moral domain	The character of war is expanding from just traditional force-on-force engagements to include more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to 'win the peace' must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations. This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
12.1.4	Three Domains of War: Physical, Mental and Moral	Need to develop capabilities that act in the information and moral domain	The character of war is expanding from just traditional force-on-force engagements to include more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to 'win the peace' must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations. This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
12.1.5	Three Domains of War: Physical, Mental and Moral	Need to develop capabilities that act in the information and moral domain	The character of war is expanding from just traditional force-on-force engagements to include more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to 'win the peace' must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations.	Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
12.1.5	Three Domains of War: Physical, Mental and Moral	Need to develop capabilities that act in the information and moral domain	This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain. (cont'd)	Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment
12.2.1	Three Domains of War: Physical, Mental and Moral	Cyber security	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	Capable of controlling/influencing the cyberspace environment
12.2.2	Three Domains of War: Physical, Mental and Moral	Cyber security	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	Capable of being able to operate without control of the cyberspace environment
12.2.3	Three Domains of War: Physical, Mental and Moral	Cyber security	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	Capable of monitoring emerging and developing technology in the commercial and defence sectors
12.2.4	Three Domains of War: Physical, Mental and Moral	Cyber security	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	Capable of providing Information Assurance (IA) services for the implementation of a Networking and Information Infrastructure (NII)
12.2.5	Three Domains of War: Physical, Mental and Moral	Cyber security	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
12.2.6	Three Domains of War: Physical, Mental and Moral	Cyber security	To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battle ground? What are doctrine and ROEs for cyberspace?	Capable of acting without access to cyberspace
12.3.1	Three Domains of War: Physical, Mental and Moral	Balance of investments in the three domains	Despite the growing focus on campaigns to win the 'hearts and minds' and an effects-based approach to operations, there will always be a requirement to maintain dominance in the physical domain.	Capable of monitoring emerging and developing technology in the commercial and defence sectors

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
12.3.1	Three Domains of War: Physical, Mental and Moral	Balance of investments in the three domains	There is a need to find a balance of investment between capabilities that act in the physical, the information and the moral domain. (cont'd)	Capable of monitoring emerging and developing technology in the commercial and defence sectors
12.3.2	Three Domains of War: Physical, Mental and Moral	Balance of investments in the three domains	Despite the growing focus on campaigns to win the 'hearts and minds' and an effects-based approach to operations, there will always be a requirement to maintain dominance in the physical domain. There is a need to find a balance of investment between capabilities that act in the physical, the information and the moral domain.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
12.3.3	Three Domains of War: Physical, Mental and Moral	Balance of investments in the three domains	Despite the growing focus on campaigns to win the 'hearts and minds' and an effects-based approach to operations, there will always be a requirement to maintain dominance in the physical domain. There is a need to find a balance of investment between capabilities that act in the physical, the information and the moral domain.	Capable of modeling the interaction between the physical, mental and moral domains
12.3.4	Three Domains of War: Physical, Mental and Moral	Balance of investments in the three domains	Despite the growing focus on campaigns to win the 'hearts and minds' and an effects-based approach to operations, there will always be a requirement to maintain dominance in the physical domain. There is a need to find a balance of investment between capabilities that act in the physical, the information and the moral domain.	Capable of modelling cost of various force structure options
12.3.5	Three Domains of War: Physical, Mental and Moral	Balance of investments in the three domains	Despite the growing focus on campaigns to win the 'hearts and minds' and an effects-based approach to operations, there will always be a requirement to maintain dominance in the physical domain. There is a need to find a balance of investment between capabilities that act in the physical, the information and the moral domain.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
12.4.1	Three Domains of War: Physical, Mental and Moral	Acceptance of the tenets of irregular warfare	Societal, political and military understanding of the character of irregular (unrestricted, continuous) warfare and acceptance of the requirements it poses. Critical elements are, e.g., public resilience, an effective integration of instruments of state power and 'staying power', both physically and mentally. An important prerequisite is to have the ability to map the mental and moral domains. Fields such as sociology and anthropology must be tapped to establish methodologies that will include the mental and moral domains, both in a strategic sense and for operational purposes (intelligence preparation of the mental and moral "battlefield").	Capable of monitoring emerging and developing technology in the commercial and defence sectors

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
12.4.2	Three Domains of War: Physical, Mental and Moral	Acceptance of the tenets of irregular warfare	Societal, political and military understanding of the character of irregular (unrestricted, continuous) warfare and acceptance of the requirements it poses. Critical elements are, e.g., public resilience, an effective integration of instruments of state power and ‘staying power’, both physically and mentally. An important prerequisite is to have the ability to map the mental and moral domains. Fields such as sociology and anthropology must be tapped to establish methodologies that will include the mental and moral domains, both in a strategic sense and for operational purposes (intelligence preparation of the mental and moral “battlefield”).	Capable of researching and executing asymmetric strategies that mitigate the need for large numbers of forces
12.4.3	Three Domains of War: Physical, Mental and Moral	Acceptance of the tenets of irregular warfare	Societal, political and military understanding of the character of irregular (unrestricted, continuous) warfare and acceptance of the requirements it poses. Critical elements are, e.g., public resilience, an effective integration of instruments of state power and ‘staying power’, both physically and mentally. An important prerequisite is to have the ability to map the mental and moral domains. Fields such as sociology and anthropology must be tapped to establish methodologies that will include the mental and moral domains, both in a strategic sense and for operational purposes (intelligence preparation of the mental and moral “battlefield”).	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
13.1.1	Coalition Operations	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of modelling cost of various force structure options
13.1.2	Coalition Operations	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
13.1.3	Coalition Operations	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable to assure access to common resources in a variable configuration of coalitions
13.1.4	Coalition Operations	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable to determine in which institutional setting (EU, NATO, UN) a particular endeavour can be carried out optimally

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
13.1.5	Coalition Operations	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of dynamically managing budgets within a complex environment
13.1.6	Coalition Operations	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
13.2.1	Coalition Operations	Legal issues and caveats	Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.	Capable of generating coherent and integrated policy options
13.2.2	Coalition Operations	Legal issues and caveats	Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
13.2.3	Coalition Operations	Legal issues and caveats	Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
13.2.4	Coalition Operations	Legal issues and caveats	Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
13.2.5	Coalition Operations	Legal issues and caveats	Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.	Capable to create a workable legal framework in (and for) coalition operations while doing justice to national legal considerations

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
13.3.1	Coalition Operations	Capability pooling, sharing, specializing	Niche capabilities and role specialization. Critical reliance on assets of one country and the risk that that country's need will trump the coalition need. Span of metrics and benchmarking efforts. Need for interoperability / open standards across DOTMLPFI. Needs for capabilities and information models/architectures to be 'born' interoperable.	Capable of generating coherent and integrated policy options
13.3.2	Coalition Operations	Capability pooling, sharing, specializing	Niche capabilities and role specialization. Critical reliance on assets of one country and the risk that that country's need will trump the coalition need. Span of metrics and benchmarking efforts. Need for interoperability / open standards across DOTMLPFI. Needs for capabilities and information models/architectures to be 'born' interoperable.	Capable of developing information/weapons systems with open architectures and common standards that will incorporate legacy systems
13.3.3	Coalition Operations	Capability pooling, sharing, specializing	Niche capabilities and role specialization. Critical reliance on assets of one country and the risk that that country's need will trump the coalition need. Span of metrics and benchmarking efforts. Need for interoperability / open standards across DOTMLPFI. Needs for capabilities and information models/architectures to be 'born' interoperable.	Capable of assessing the optimal level of multi-nationality for a given capability
14.1.1	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of preserving space as a sanctuary for NATO assets
14.1.2	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of acting without access to space assets
14.1.3	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
14.1.4	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of space traffic management

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
14.1.5	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of employing lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage
14.1.6	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of protecting space assets and communication links
14.1.7	Space is Opening Up	Critical dependence upon space assets	The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.	Capable of intercepting and destroying in-flight ballistic missiles
14.2.1	Space is Opening Up	Legal issues and caveats	Without a clear understanding of the legalities of space usage or control the possibilities of accidents or deliberate actions being construed as an "Act of War" rise considerably. Potential state and non-state opponents, enemies and aggressors could exploit the "grey areas" and cause undo tensions in the world. Placing weapons in space to protect space assets could lead to placement of offensive weapons as well. Need for an arms control system. Clearly defined military responsibilities in this domain will help draw the line on what are acceptable roles and missions and what are not. Rules/controls are required for, e.g., aerospace control and management, debris handling, weaponization, commercial usage.	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities
14.2.2	Space is Opening Up	Legal issues and caveats	Without a clear understanding of the legalities of space usage or control the possibilities of accidents or deliberate actions being construed as an "Act of War" rise considerably. Potential state and non-state opponents, enemies and aggressors could exploit the "grey areas" and cause undo tensions in the world. Placing weapons in space to protect space assets could lead to placement of offensive weapons as well. Need for an arms control system. Clearly defined military responsibilities in this domain will help draw the line on what are acceptable roles and missions and what are not. Rules/controls are required for, e.g., aerospace control and management, debris handling, weaponization, commercial usage.	Capable of developing systems with open architectures and common standards

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
14.3.1	Space is Opening Up	Ubiquity of supply	Commercial interest in the lucrative space arena allow for more players to have access to increased situational awareness which would otherwise be limited. Privatization of services that might be applied military permits misuse (or smart use) by state and non-state opponents. This causes risks to NATO's capabilities.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
14.4.1	Space is Opening Up	Technology sharing	The large expense related to technology development limits the number of countries on the leading edge of military exploitation of space. If there is severe limitation or disruption in the technology flow to all NATO countries interoperability and distrust issues will arise.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
15.1.1	Cost Escalation	High-technology costs are increasing	Cutting-edge weapons systems and system-of-systems continue to rise in cost. Simultaneously, defence budgets remain stable or decrease in real terms. In a platform-centric paradigm, this means fewer platforms available/ affordable. In a network-centric paradigm, transformation and system-of-systems development may be unaffordable. In general this trend, certainly nationally, results in unaffordable capabilities.	Capable of modelling cost of various force structure options
15.1.2	Cost Escalation	High-technology costs are increasing	Cutting-edge weapons systems and system-of-systems continue to rise in cost. Simultaneously, defence budgets remain stable or decrease in real terms. In a platform-centric paradigm, this means fewer platforms available/ affordable.In a network-centric paradigm, transformation and system-of-systems development may be unaffordable. In general this trend, certainly nationally, results in unaffordable capabilities.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
15.1.3	Cost Escalation	High-technology costs are increasing	Cutting-edge weapons systems and system-of-systems continue to rise in cost. Simultaneously, defence budgets remain stable or decrease in real terms. In a platform-centric paradigm, this means fewer platforms available/ affordable. In a network-centric paradigm, transformation and system-of-systems development may be unaffordable. In general this trend, certainly nationally, results in unaffordable capabilities.	Capable of generating coherent and integrated policy options

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
15.1.4	Cost Escalation	High-technology costs are increasing	Cutting-edge weapons systems and system-of-systems continue to rise in cost. Simultaneously, defence budgets remain stable or decrease in real terms. In a platform-centric paradigm, this means fewer platforms available/ affordable. In a network-centric paradigm, transformation and system-of-systems development may be unaffordable. In general this trend, certainly nationally, results in unaffordable capabilities.	Capable of developing modular systems ready for technology insertion
15.1.5	Cost Escalation	High-technology costs are increasing	Cutting-edge weapons systems and system-of-systems continue to rise in cost. Simultaneously, defence budgets remain stable or decrease in real terms. In a platform-centric paradigm, this means fewer platforms available/ affordable. In a network-centric paradigm, transformation and system-of-systems development may be unaffordable. In general this trend, certainly nationally, results in unaffordable capabilities.	Capable of developing information/ weapons systems with open architectures and common standards that will incorporate legacy systems
15.2.1	Cost Escalation	Running costs are escalating	Trend for real wage growth, coupled with more complex equipment and more demanding legislation makes operating costs prohibitively expensive (Baumol's cost disease). Simultaneously, defence budgets remain stable or decrease in real terms. Nations are unable to afford the 'cost spike' for new equipment, because current running costs absorb most of the budget. Also the cost of commodities might (continue to) rise to extreme levels.	Capable of modelling cost of various force structure options
15.2.2	Cost Escalation	Running costs are escalating	Trend for real wage growth, coupled with more complex equipment and more demanding legislation makes operating costs prohibitively expensive (Baumol's cost disease). Simultaneously, defence budgets remain stable or decrease in real terms. Nations are unable to afford the 'cost spike' for new equipment, because current running costs absorb most of the budget. Also the cost of commodities might (continue to) rise to extreme levels.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
15.2.3	Cost Escalation	Running costs are escalating	Trend for real wage growth, coupled with more complex equipment and more demanding legislation makes operating costs prohibitively expensive (Baumol's cost disease).	Capable of generating coherent and integrated policy options

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
15.2.3	Cost Escalation	Running costs are escalating	Simultaneously, defence budgets remain stable or decrease in real terms. Nations are unable to afford the 'cost spike' for new equipment, because current running costs absorb most of the budget. Also the cost of commodities might (continue to) rise to extreme levels. (cont'd)	Capable of generating coherent and integrated policy options
15.3.1	Cost Escalation	Costs of actual operations are escalating	The real cost of operations far exceeds budget lines and estimates, resulting in Nations not willing to commit to operations, certainly not long-lasting ones. Balance is needed between the vital interests at stake and the military investments to protect those actively.	Capable of modelling cost of various force structure options
15.3.2	Cost Escalation	Costs of actual operations are escalating	The real cost of operations far exceeds budget lines and estimates, resulting in Nations not willing to commit to operations, certainly not long-lasting ones. Balance is needed between the vital interests at stake and the military investments to protect those actively.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
15.3.3	Cost Escalation	Costs of actual operations are escalating	The real cost of operations far exceeds budget lines and estimates, resulting in Nations not willing to commit to operations, certainly not long-lasting ones. Balance is needed between the vital interests at stake and the military investments to protect those actively.	Capable of generating coherent and integrated policy options
16.1.1	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
16.1.2	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of generating coherent and integrated policy options
16.1.3	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
16.1.4	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
16.1.5	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour
16.1.6	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment
16.1.7	Political Transformation	Achieving campaign level surprise	Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by pol-mil decision-making.	Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa
16.2.1	Political Transformation	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of modelling cost of various force structure options
16.2.2	Political Transformation	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of measuring, analysing, predicting and anticipating risk within a complex environment
16.2.3	Political Transformation	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of generating coherent and integrated policy options
16.2.4	Political Transformation	Burden sharing	Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.	Capable of establishing the cost of ongoing operations and of giving a decent estimate for possible future operations

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
16.3.1	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of conducting civil-military cooperation in an inter-agency environment
16.3.2	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of formulating and executing shared and realistic actions
16.3.3	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of formulating and executing shared and realistic actions
16.3.4	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements
16.3.5	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
16.3.6	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs
16.3.7	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
16.3.8	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of undertaking in-depth foresight analysis to develop models of the future security environment

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
16.3.9	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of realistic computer modelling and simulation to support military operations training, experimentation, decision-making and comprehensive approach planning
16.3.10	Political Transformation	Comprehensive approach	Embedding military capability/efforts in inter-agency endeavours.	Capable of advanced distributed learning, training/exercises in a multi-level security environment through a single, comprehensive network architecture
17.1.1	The Role of Information and the Media	24-hour media cycle	The Alliance will work in an environment where the news media will be pervasive and will have access to (near) real-time transmission capabilities to a global audience. This could harm military operations. Or is this something that the military can try to influence or take advantage of? The speed with which media can report on incidents during operations far exceeds ability of Commanders to present a comprehensive insight into the NATO 'side of the story'. This can most certainly result in incorrect, possibly volatile, information being spread through a theatre of operations bringing about serious consequences.	Capable of controlling/influencing the cyberspace environment
17.1.2	The Role of Information and the Media	24-hour media cycle	The Alliance will work in an environment where the news media will be pervasive and will have access to (near) real-time transmission capabilities to a global audience. This could harm military operations. Or is this something that the military can try to influence or take advantage of? The speed with which media can report on incidents during operations far exceeds ability of Commanders to present a comprehensive insight into the NATO 'side of the story'. This can most certainly result in incorrect, possibly volatile, information being spread through a theatre of operations bringing about serious consequences.	Capable of (near) real-time news processing

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
17.1.3	The Role of Information and the Media	24-hour media cycle	The Alliance will work in an environment where the news media will be pervasive and will have access to (near) real-time transmission capabilities to a global audience. This could harm military operations. Or is this something that the military can try to influence or take advantage of? The speed with which media can report on incidents during operations far exceeds ability of Commanders to present a comprehensive insight into the NATO ‘side of the story’. This can most certainly result in incorrect, possibly volatile, information being spread through a theatre of operations bringing about serious consequences.	Capable of designing effective media strategies
17.2.1	The Role of Information and the Media	Information operations and media bias	The media reporting on Alliance operations can influence the attitudes of the indigenous residents. Due to the proliferation of technology that gives anyone access to a wide audience, adversaries and media organizations with different agendas could seek to use the mediums of the internet, television, radio, etc., to promulgate positions that are negative to NATO. Information operations will have an impact particularly in the mental and moral domains, and, most certainly, will have an impact on the physical over time. The high numbers of transmission channels for information operations and the high level of access to the supporting technology make information operations a likely component of Alliance operations. Due to complexity of future operations and the high likelihood of these operations requiring, at least, the tacit approval of the indigenous population, the possible impact of enemy information operations could be significant.	Capable of assessing in near real-time open sources of information for relevant data
17.2.2	The Role of Information and the Media	Information operations and media bias	The media reporting on Alliance operations can influence the attitudes of the indigenous residents. Due to the proliferation of technology that gives anyone access to a wide audience, adversaries and media organizations with different agendas could seek to use the mediums of the internet, television, radio, etc., to promulgate positions that are negative to NATO. Information operations will have an impact particularly in the mental and moral domains, and, most certainly, will have an impact on the physical over time.	Capable of exploiting one’s own media strategy in information space

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
17.2.2	The Role of Information and the Media	Information operations and media bias	The high numbers of transmission channels for information operations and the high level of access to the supporting technology make information operations a likely component of Alliance operations. Due to complexity of future operations and the high likelihood of these operations requiring, at least, the tacit approval of the indigenous population, the possible impact of enemy information operations could be significant. (cont'd)	Capable of exploiting one's own media strategy in information space
17.2.3	The Role of Information and the Media	Information operations and media bias	The media reporting on Alliance operations can influence the attitudes of the indigenous residents. Due to the proliferation of technology that gives anyone access to a wide audience, adversaries and media organizations with different agendas could seek to use the mediums of the internet, television, radio, etc., to promulgate positions that are negative to NATO. Information operations will have an impact particularly in the mental and moral domains, and, most certainly, will have an impact on the physical over time. The high numbers of transmission channels for information operations and the high level of access to the supporting technology make information operations a likely component of Alliance operations. Due to complexity of future operations and the high likelihood of these operations requiring, at least, the tacit approval of the indigenous population, the possible impact of enemy information operations could be significant.	Capable of countering opponent's use of information space
17.3.1	The Role of Information and the Media	Media as an intelligence source for the enemy	The proliferation of media and mediums through which information related to operations can be accessed has significantly increased the use of media reports as sources for intelligence. Adversaries have used traditional media reports, as well as more non-traditional sources such as YouTube and Google, to access geographic data and receive results of attacks and assessments of the quality of tactics. Ambient intelligence?	Capable of (near) real-time news processing
17.3.2	The Role of Information and the Media	Media as an intelligence source for the enemy	The proliferation of media and mediums through which information related to operations can be accessed has significantly increased the use of media reports as sources for intelligence.	Capable of exploiting information space for disinforming opponents

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
17.3.2	The Role of Information and the Media	Media as an intelligence source for the enemy	Adversaries have used traditional media reports, as well as more non-traditional sources such as YouTube and Google, to access geographic data and receive results of attacks and assessments of the quality of tactics. Ambient intelligence? (cont'd)	Capable of exploiting information space for disinforming opponents
18.1.1	Super-Empowered Individuals	Massive destruction power in the hands of a single person	Proliferation of relatively low-cost, easy to obtain dual-use technology with extreme destructive capabilities leads to this new, difficult to predict/control threat.	Capable of monitoring emerging and developing technology in the commercial and defence sectors
18.1.2	Super-Empowered Individuals	Massive destruction power in the hands of a single person	Proliferation of relatively low-cost, easy to obtain dual-use technology with extreme destructive capabilities leads to this new, difficult to predict/control threat.	Capable of detection, warning and neutralization of full spectrum of CBRN agents or contaminants and identifying the type of agent or contaminant and the area affected
18.1.3	Super-Empowered Individuals	Massive destruction power in the hands of a single person	Proliferation of relatively low-cost, easy to obtain dual-use technology with extreme destructive capabilities leads to this new, difficult to predict/control threat.	Capable of consequence management
18.1.4	Super-Empowered Individuals	Massive destruction power in the hands of a single person	Proliferation of relatively low-cost, easy to obtain dual-use technology with extreme destructive capabilities leads to this new, difficult to predict/control threat.	Capable of employing lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage
18.1.5	Super-Empowered Individuals	Massive destruction power in the hands of a single person	Proliferation of relatively low-cost, easy to obtain dual-use technology with extreme destructive capabilities leads to this new, difficult to predict/control threat.	Capable of employing non or less lethal precision strikes from land, sea, air and space with assurance and minimum risk of collateral damage
18.2.1	Super-Empowered Individuals	Individuals posing a threat blending in with the environment	Finding, identifying, tracking and taking action against (individual) opponents immersed in a local population is highly challenging. More so if this has to be done non-obtrusive and (in case of action) without unintended collateral damage. Getting inside the decision cycle by anticipating or even predicting 'next moves' is even more complex and certainly needs to develop understanding of the drivers/motivations, modus operandi, etc., of such opponents.	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements

Theme-Issue-Capability or TIC Number	Theme	Issue	Issue Description	Capability
18.2.2	Super-Empowered Individuals	Individuals posing a threat blending in with the environment	Finding, identifying, tracking and taking action against (individual) opponents immersed in a local population is highly challenging. More so if this has to be done non-obtrusive and (in case of action) without unintended collateral damage. Getting inside the decision cycle by anticipating or even predicting ‘next moves’ is even more complex and certainly needs to develop understanding of the drivers/motivations, modus operandi, etc., of such opponents.	Capable of processing, fusing and exploiting the imagery, data, information and intelligence provided by all-source Alliance Joint ISR (JISR) capabilities and generating products that end-users can readily assimilate
18.2.3	Super-Empowered Individuals	Individuals posing a threat blending in with the environment	Finding, identifying, tracking and taking action against (individual) opponents immersed in a local population is highly challenging. More so if this has to be done non-obtrusive and (in case of action) without unintended collateral damage. Getting inside the decision cycle by anticipating or even predicting ‘next moves’ is even more complex and certainly needs to develop understanding of the drivers/motivations, modus operandi, etc., of such opponents.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
18.2.4	Super-Empowered Individuals	Individuals posing a threat blending in with the environment	Finding, identifying, tracking and taking action against (individual) opponents immersed in a local population is highly challenging. More so if this has to be done non-obtrusive and (in case of action) without unintended collateral damage. Getting inside the decision cycle by anticipating or even predicting ‘next moves’ is even more complex and certainly needs to develop understanding of the drivers/motivations, modus operandi, etc., of such opponents.	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour
18.2.5	Super-Empowered Individuals	Individuals posing a threat blending in with the environment	Finding, identifying, tracking and taking action against (individual) opponents immersed in a local population is highly challenging. More so if this has to be done non-obtrusive and (in case of action) without unintended collateral damage. Getting inside the decision cycle by anticipating or even predicting ‘next moves’ is even more complex and certainly needs to develop understanding of the drivers/motivations, modus operandi, etc., of such opponents.	Capable of improved timely, accurate, complete and relevant planning and decision support to improve feedback to decision-makers and other staffs

Annex E – RESULTS OF THE LITERATURE SEARCH

E.1 LITERATURE SEARCH INPUT FROM THE CZECH REPUBLIC

E.1.1 Theme 5, 14

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: Agent-Based Approach to Free-Flight Planning, Control, and Simulation.

Author: Michal Pechoucek and David Sislak.

Corp Auth: Czech Technical University Prague, (Czech Republic).

Abstract: Air traffic is extremely busy and increasing daily. In fact, the aviation industry is planning for rapid growth worldwide. Boeing anticipates that cargo will triple over the next 20 years. Air traffic control faces yet another critical challenge – ever-increasing requirements for air traffic operation involving manned and unmanned aerial assets. Small unmanned aerial vehicles – often used, for example, for emergency surveillance and monitoring – must be able to operate near airports with heavy civilian air traffic. Clearly, current air traffic management systems can't efficiently support such requirements or handle much more than the current density. Sophisticated, intelligent technology is needed for further growth in the capacity and safety of worldwide, mixed initiative air traffic.

Report No.: IEEE Intelligent Systems, 2009, Vol. 24.

Pages: pp. 14-17.

http://agents.felk.cvut.cz/cgi-bin/docarc/public.pl/document/213/mex2009010014.pdf

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: Autonomous UAV Surveillance in Complex Urban Environments.

Author: Eduard Semsch, Michal Jakob, Dusan Pavlicek, Michal Pechoucek and David Sislak.

Corp Auth: Czech Technical University Prague, (Czech Republic).

Abstract: It addresses the problem of multi-UAV surveillance in complex urban environments with occlusions. The problem consists of coordinating the flight of UAVs with on-board cameras so that the coverage and recency of the information about a designated area is maximized. In contrast to the existing work, sensing constraints due to occlusions and UAV flight constraints are modeled realistically and taken into account. We propose a novel occlusion-aware surveillance algorithm based on a decomposition of the surveillance problem into a variant of the three-dimensional art gallery problem and the multi-traveling salesmen problem for Dubins vehicles. The algorithm is thoroughly evaluated on the high-fidelity AGENTFLY UAV simulation testbed which accurately models all constraints and effects involved. The results confirm the importance of occlusion-aware flight path planning, in particular in the case of narrow street areas and low UAV flight altitudes.

Report No.: Proceedings of ICAPS 2009 Workshop on Bridging the Gap Between Task and Motion Planning, 2009.

http://agents.felk.cvut.cz/cgi-bin/docarc/public.pl/document/255/ICAPS09-WS9-Semsch-p63_70.pdf

E.1.2 Theme 2, 13

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: A Knowledge-Based Approach to Coalition Formation.

Author: Michal Pechoucek, Vladimir Marik and Jaroslav Barta.

Corp Auth: Czech Technical University Prague, (Czech Republic).

Abstract: Planning humanitarian relief operations is a challenge for several reasons, not the least of which is that the involved players are often both vaguely linked and hesitant to share information. Typically, coalitions are organized through a central planning component that distributes the plan with collaborative agents. We suggest an alternative knowledge-based approach where all agents collaborate in forming coalitions and planning humanitarian and peace-keeping missions. We developed our CPlanT multi-agent knowledge-based system with two goals in mind: 1) Simplify coalition formation, and thus make it more efficient; and 2) Maintain the confidentiality of agents' private information.

Report No.: IEEE Intelligent Systems, 2002, Vol. 17.

Pages: pp. 17-25.

ISSN 1094-7167.

http://agents.felk.cvut.cz/cgi-bin/docarc/public.pl/document/22/x3pech.pdf

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: Role of acquaintance models in agent's private and semi-knowledge disclosure.

Author: Michal Pechoucek, Vladimir Marik and Jaroslav Barta.

Corp Auth: Czech Technical University Prague, (Czech Republic).

Abstract: The organizational architecture of the multi-agent systems and the structure of social knowledge that the members of the community administer are critical factors for assuring such patterns of information exchange that keep agents private knowledge confidential. In this paper we will introduce the concept of agents' private and semi-private knowledge and we will explain the difference between the Alliance – a semi-permanent organizational structure and a coalition – a goal-oriented, non-permanent organizational structure. We will provide the reader with an analysis on how does the agents' social knowledge, stored in the tri-base acquaintance model, contributes to permanent confidentiality of agents' private knowledge, preferences, decision-making models, resources, etc. The study has been experimentally verified in the domain of planning for humanitarian relief operations within a high number of hardly collaborating and vaguely linked non-governmental organizations is a challenging problem.

Report No.: 2006 Elsevier B.V, Knowledge-Based Systems, 2006.

Pages: pp. 259-271.

http://agents.felk.cvut.cz/cgi-bin/docarc/public.pl/document/105/sdarticle.pdf

E.1.3 Theme 1, 4

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: Adversarial Search with Procedural Knowledge Heuristic.

Author: Viliam Lisy, Branislav Bosansky, Michal Jakob and Michal Pechoucek.

Corp Auth: Czech Technical University Prague, (Czech Republic).

Abstract: We introduce an adversarial planning algorithm based on game tree search, which is applicable in large-scale multi-player domains. In order to tackle the scalability issues of game tree search, the algorithm utilizes procedural knowledge capturing how individual players tend to achieve their goals in the domain; the information is used to limit the search only to the part of the game tree that is consistent with pursuing players' goals. We impose no specific requirements on the format of the procedural knowledge; any programming language or agent specification paradigm can be employed. We evaluate the algorithm both theoretically and empirically, confirming that the proposed approach can lead to a substantial search reduction with only a minor negative impact on the quality of produced solutions.

Report No.: The Eighth International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2009), 2009.

http://agents.felk.cvut.cz/cgi-bin/docarc/public.pl/document/218/16_88_FP_0465.pdf

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: Using Player Models to Improve Robustness of HTN Plans in Multi-Agent Domains.

Author: Eduard Semsch, Michal Jakob, Jan Doubek and Michal Pechoucek.

Corp Auth: Czech Technical University Prague, (Czech Republic).

Abstract: When multiple agents act concurrently towards achieving their goals in a shared environment, interactions between their actions may arise, affecting the outcome of their plans. We propose an approach to planning in such environments, termed interference robustness optimization planning that builds upon the HTN planning paradigm and extends it with explicit consideration and optimization of plan robustness. Plan robustness is calculated from the domain model and probabilistic models of other agents in the domain. A method is presented for automatic conversion of standard HTN planning tasks into planning tasks whose output maximizes plan success probability. The method is evaluated on a test domain based on a realistic multi-agent disaster relief scenario. The empirical results indicate that the effectiveness of the method depends strongly on the predictability of other agents' behaviour and the ratio of interaction action pairs. For any values of these control parameters, the proposed method significantly outperforms standard HTN planning.

Report No.: Proceedings of the 27th Workshop of the UK Planning and Scheduling Special Interest Group, 2008.

http://agents.felk.cvut.cz/cgi-bin/docarc/public.pl/document/215/semsch-PlanSIG2008-submission.pdf

E.1.4 Theme 9

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: Using of Nanofibres for Air and Water Treatment.

Author: Cernik, M. and Lederer, T.

Corp Auth: Technical University of Liberec, (Czech Republic).

Abstract: TUL holds a worldwide patent for manufacturing nanofibre structures, which can be used as passive filtration material with very high specific surface or adapted to fix the other nanoparticles to textile materials with high homogeneity of distribution. The supplementation of other nanoparticles (Ag like

biocid, TiO2, V2O5, Pd or Pt like catalyst) can improve the characteristic of nanofibre structures as the activated filtration material for special filters for water and air treatment. The origin of this development were environmental purposes for treatment of wastewaters and flue-gas from incinerators (inherent xenobiotics like PCB, dioxins and others). These new nanofibre-based filters can be applied as personal or car air-filters for military purposes or special filters for treatment of water for personal purposes (disinfection, detoxication). Nanofibres can be applied alone or as a coating layer of macroscopic fibres. Such structures have been intensively tested by TUL in different water and air treatment technologies. Another possible application of bacteria-resistant nanofibres is for membrane surface modification, where coating of the membrane surface with nanofibres or adding a nanofibre layer between existing layers can decrease fouling of the separation membranes, which are usually used for treatment of water.

Classification: UNCLASSIFIED.

Distribution Statement: Approved for public release; Distribution unlimited.

Title: A New Traveling Wave Phenomenon of Dictyostelium in the Presence of cAMP.

Author: Ševčíková, H., Čejková, J., Krausová, L., Přibyl, M., Štěpánek, F. and Marek, M.

Corp Auth: Department of Chemical Engineering and Center for Non-Linear Dynamics of Chemical and Biological Systems, Institute of Chemical Technology Prague, Technicka 5, 166 28 Praha 6, Czech Republic.

Abstract: The emergence of wave patterns in chemical and biological systems is of interest for the understanding of development, differentiation, signaling, and other phenomena. This work reports a new type of wave pattern – called the “global wave” – which was observed in populations of Dictyostelium discoideum cells exposed to an excess of cyclic adenosine- 3′, 5′- monophosphate (cAMP) added to the supporting agar. It has been found that the addition of different amounts of cAMP to the agar leads to important deviations from the standard course of aggregation:

i) The formation and propagation of a global wave that has not been observed before;
ii) The delayed onset or absence of cAMP waves patterning;
iii) An atypical mechanism of cells clustering; and
iv) A faster or incomplete developmental cycle.

It is suggested that the global wave is a chemotactic response of the Dictyostelium cells to a wave of the cAMP concentration.

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E.1.5 To All Themes

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Annex F – PRELIMINARY REVIEW OF THE PHASE IV RESULTS BY CAPABILITY AREA

As part of a read ahead package to be provided to the MNE participants in advance of the MNE, the following Preliminary Review of the Phase IV Literature Review and Bibliography was prepared by one of the members of the Study Group.

> *I question the prudence of announcing to the world that we will not participate in certain forms of conflict then sealing the invitation for those who wish us ill to practice those forms by rendering ourselves virtually impotent.*
>
> LTC. Donald B. Vought, May 1977
>
> *Nothing is certain except that we face innumerable uncertainties; but simply recognizing that fact provides a vital starting point, and is, of course, far better than being blindly unaware of how our world is changing.*
>
> Paul Kennedy, Preparing for the Twenty-First Century

Joint Operations 2030 had as its mandate to examine technological solutions to capability requirements that will arise out to a time horizon of 2030. The result is emerging technology that may be relevant to development of a solution concept for a capability requirement foreseen in the 2030 time frame. R&T in these Focus Areas should commence/continue to ensure the development of these technologies and their related systems within the time horizon. Answers the question of what technologies should be invested in today to ensure the success of Alliance forces in the future. Cannot foresee/predict what technologies will be available in the time period as it is impossible to forecast what scientific discoveries will occur in the interim.

These extractions of the Capability Requirements are designed to take from the research literature searches and information gathered in the course of the JO 2030 Solution Solicitation Sessions and bridge the gap between Capability Requirements and Technology Focus Areas (TFAs). The TFAs will form the basis for answering the remit of the study. TICs for which little or no data was gathered will be reflected as such within the extensions. The facilitators for these TICs will be required to do some more research to provide background material for subsequent group discussions during the MNE.

6 X TICs – Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour

It became clear quite early in the research process that this capability description was too limited to aspects related to possible adversaries and had to be extended to friendly and neutral forces as well. This was one of the most examined capability areas as it has numerous linkages as an enabler to other capabilities areas. It is also a current focus of many national R&T efforts. This is a broad research area that incorporates gathering, sorting, analyzing and presenting enormous amounts of data at the right time and in the right format for end-users. The capability to build a holistic knowledge base will make physical demands on bandwidth, software and underlying algorithms and sufficiently dense data gathering capabilities to bring the required information into the knowledge base. Cognitive demands related to operator attentiveness, comprehension and prioritization will also come to the forefront.

One of the critical elements highlighted during the discovery effort of the SSSs was the need to be able to aggregate structured and unstructured information (text, video, voice, etc.) into formats that can be archived, mined, fused and shared across networks. Agent-based ontology and holonic systems are promising areas related to gathering and categorizing heterogeneous information from disparate databases/sources. Research in knowledge representation must continue in order to make data accessible for automated mining/analysis. Software architectural patterns in conjunction with broad data strategies are required to harness and employ vast quantities of content. Semantic-web developments that can sort through large amounts of textual information and discern patterns and linkages will be important. Social networking websites (MySpace/ Facebook) were highlighted as the beginning of such a capability to gather and share information. Of course, multi-level security systems are an imperative to allow dissemination of the knowledge to those having both a justified need and a verified clearance without unduly interrupting the flow of information. Advanced encryption, real-time user verification and firewalls will facilitate this higher level of accessibility.

Service Oriented Architectures (SOAs) offer a compelling solution to data management needs. Some of SOA's potential gains require a level of openness that runs contrary to the culture of defence contractors. Core communications between the services and specifications need to remain non-proprietary and vendor neutral to maximize open communications between systems and realize. Ad hoc networks that can form without intervention will be required to connect all elements within the battlespace.

Operations within a battlespace necessarily deal with uncertainty, and it is necessary to determine ways to represent and encode the confidence level that exists for each piece of battlefield data. For example, as the last reported position of an entity ages, the uncertainty of where the entity is currently located grows. Therefore, a holistic knowledge-base must include the ability to encode the level of uncertainty associated with a piece of information as well as its provenance to enable follow-on analysis. This type of information must be annotated prior to input into the knowledge base. While gathering human-based intelligence, voice stress and gesture analysis may provide some basis for assessing these aspects of data. Bio-metric identification of the individuals providing the information may assist classification of the intelligence. An in-depth knowledge of indigenous culture and history would also provide a foundation for a value assessment of collected information. Anthropology provides a rich field for methodologies and taxonomies that could be beneficial to measuring trust and other traits that would affect the value of information.

To provide a timely and accurate picture of the battlespace, information is gathered from many different sources including eye witness reports, aerial photographs, sonar, radar, Synthetic Aperture Radar (SAR), Multi-Spectral Imaging (MSI), Hyper Spectral Imaging (HSI), Foliage Penetration Radar (FOPEN), Electro-Optic (EO), Infra-Red (IR) and Moving Target Imaging (MTI) data. Fusing these disparate data sources is difficult. The allocation of bandwidth to each of these sensors will also be a concern.

The immense amount of data available today and its digital distribution have increased the difficulty in gathering relevant information. Gathering the large amount of data necessary to populate a holistic knowledge base will require automated tools for deeply searching the infosphere including at level of individual databases. Web tools such as bots and spider for real-time monitoring and gathering data should be pursued. Expert system developed with heuristic characteristics will be required to assess the quality of gathered data as well as to sort and categorize it. Automated rapid, high fidelity language translation of all media will be necessary to encode data in the most appropriate language for users. This translation must recognise nuances and ambiguities of the language. The knowledge base will require also connection to sensors to gather information from the environment. This will require persistent sensors, possibly at the nano-level (dust), which will feed data into the network. These types of sensors will require enabling technologies in the power generation and materials areas. A suite of nanytes or micro-particles that react in the presence of particular chemicals could serve as a large area sensor. Changes in the reflective and re-radiant properties of the nanytes would be indicative of the presence of possible targets. Hyper-spectral wide area sensors capable of surveilling urban settings and through foliage will also be required to develop intelligence for the knowledge base.

Network/nodal analysis and other algorithms must be developed that will automate the search for patterns and valuable insight within the knowledge base in the numerous areas such political, military, economic, social, infrastructure and information. Bayesian networks, statistical analysis and hidden Markov models have demonstrated promise in this area. The body of information resident within the holistic knowledge base could be constantly updated and improved, but some capacity to undertake a rapid environmental assessment for particular operating areas must also be developed to fill in holes with the body of knowledge to support ongoing or planned operations. Cognitive modelling will allow information to be gathered, formatted and presented in such a way as to ease assimilation by operators.

Presentation of the information in a fashion and format that will facilitate its use by decision-makers and other users will also be critical. The purpose of visualization technology is to capture images in a software environment. Massive multi-player gaming and augmented/mixed virtual reality are areas that may provide rich sources of visualization examples that would improve the ability to users to assimilate the information and take appropriate actions. Augmented reality techniques whereby actual imagery and video from the battlespace can be registered with computer generated terrain data stored in geospatial databases and displayed as the virtual environments to provide situational awareness. Dynamic scene analysis and object extraction, along with speed of transferring video, are problems with visualization. Accelerating improvements in supporting technologies will significantly enhance the ability of these types of programs to provide for decision-making, mission rehearsal, communications, operational planning and war gaming. Commanders' Intent could be transmitted across the knowledge base in a format such as video that would assist all members of the force in understanding their roles. Materials science may enhance sensory perception for users so that the user actual 'feels' some aspects of the presented knowledge. The provision of access to the knowledge base down to unit level will allow for the development of a 'Lifeguard' function whereby, through reachback, personnel at the unit level will have access to cultural, political, psychological, etc., subject matter expertise that will facilitate mission accomplishment. Through real-time exchange of data with rear-based experts, assessment of human intelligence source validity, language interpretation, cultural assessments and other tasks requiring specialized skill sets not normally associated with small units could be accomplished.

High fidelity immersive training environments that provide rapid experience for decision-makers in selecting and actioning information from the knowledge base must also be developed to ensure that decision-makers have the skills and knowledge to operate in rapidly evolving environments. Dynamic Decision-Making (DDM) techniques such as developing archetypes could be applied within these environments to train personnel. Cognitive sciences can be applied beneficially in this area.

11 X TICs – Capable of measuring, analyzing, predicting and anticipating risk within a complex environment

The ability to undertake analyses of risk within complex environments will be fundamental to success in the future. It was pointed out in several events that this area of interest had been for some time the focus of many civilian institutions such as banks, insurance companies and international organisations (e.g., World Bank and International Monetary Fund). As has been highlighted during the course of the last year, these institutions have not been able to apply correctly analyses of risk in many areas leading to large losses of capital and, possibly, a global recession. Nevertheless, the work undertaken by these organisations in building models and methodologies for analysing and applying risk still serves as the leading edge of developing thought in this area.

As with many of the capabilities highlighted in this report, the development of solutions will be enabled by advancement in other areas. The development of a holistic knowledge base containing relevant information from which an analysis could be made would provide important foundational work. The ability to share information through multi-level security in the requisite format would facilitate more accurate assessments of risk within evolving circumstances.

Risk refers to the likelihood or probability for an adverse outcome. The concept of risk is applicable to an infinite set of decision problems in both military and corporate environment. Over the last several decades, the field of risk analysis encompassing methods for developing an understanding of the processes shaping the scope and nature of risks and uncertainties has evolved. Research suggests though that predictive analysis may not be feasible due to the discontinuous nature and inherent unpredictability of the environment. New types of risks have emerged from growing complexity within the environment:

- Inherited risk;
- New sources of risk (e.g., cyber security risks);
- Risk from combinatorial effects;
- Risk from cascading consequences; and
- Risk from emergent threats.

The Alliance would benefit from a permanent maintained and continuously updated risk register that would list possible events that would trigger some response. As in normal risk analysis, actions could be taken then that would prevent, reduce, mitigate or transfer the resulting risk of occurrence and consequences, or exploit and enhance opportunities. These actions should be planned in consultation with other international bodies, national government and non-government organisations.

Principal Component Analysis (PCA) is an important tool that can be used to determine the primary components driving variability within a set of data. This will allow decision-makers to prioritise actions, and scarce resources, on those principal components that will have the most effect on the outcome. With the reduction of complex material down to a simpler structure, decision-makers will be in a better position to develop strategies to address risk. In a social context, statistical methods can extract a few clusters that correlate to observed behaviour but to be accurate these models must have sufficient data on the underpinning social theories.

Emerging thought on complex adaptive systems will allow risk structures to be analysed within rapidly evolving environments. Agent-based modelling, advanced simulation and systems dynamics will provide tools for developing appropriate responses to risk. Valid human, social, cultural and behaviour models will allow for a fuller description of risk. Resilience engineering model-based assessment and process measures may provide for the ability to anticipate changes in risk as the environment changes or time and allow for the development of timely responses. Game theory can serve us in such analyses by providing a framework for probing the inextricable connections between our adversaries’ decision problems and our own.

In the area of disaster resilience communities, key characteristics have been identified:

- Relevant hazards are recognized and understood;
- Communities at risk know when a hazard event is imminent (improved forecasting and prediction) supported by real-time data collection and interpretation;
- Disaster resistant designs and materials; and
- Reducing the vulnerability of interdependent critical infrastructure.

14.1.2 – Capable of acting without access to space

The technological advantage of the West is eroding as globalisation and proliferation foster new foreign space competitors. Global and domestic factors are having significant effects on the volatility, uncertainty, complexity and ambiguity of the strategic environment and bringing the importance of space systems to the forefront. The growing reliance of the Alliance on space-borne systems for communications, navigation, intelligence and weather observation could leave it vulnerable if these systems were lost.

The likely development of precise anti-satellite capabilities, jamming or other methods, including electro-magnetic pulse, of denying information derived from space systems will demand that the Alliance counter with the ability to operate either rapidly move to alternative sources or operate without this information. The entry into operation over the coming years of GMES (Global Monitoring for Environment and Security)/ Kopernikus is likely to reinforce this reliance and the corresponding need to consider operations without access to space information. There is a school of thought that says that satellites are inherently vulnerable and should not be depended on for critical military functions.

Development of rapid alternatives once space systems have been denied could include options to replace satellites. Rapid replacement of satellites could be accomplished by having back-up satellites parked in storage orbits waiting to be called upon. These back-up systems would have to be disguised or in some way protected (armour, camouflage, higher orbits, etc.) to ensure that they do not suffer the same fate as their predecessor prior to entering into operation. Cheaper and faster launch options that could insert new systems in orbit after the original system is lost would also be able to limit the gap in coverage. Space systems with the ability to rendezvous with and investigate other satellites to determine their purpose could allow for intervention prior to the engagement of space-borne anti-satellite systems. Investing in the broadening the capability packages carried on-board civilian satellites could allow for swift replacement.

A priority could be to develop defences that prevent the use of lasers (infra-red or visible) to dazzle or blind the satellite possibly resulting in permanent damage to optics or focal plane arrays. There will be a requirement to deal with a threat of laser attack that could force the necessity to turn the sensor away from the AOR in order to save the asset. Measures to address the jamming of synthetic aperture radar or uplinks/ downlinks will need to be developed.

Rapid deployment of long endurance UAVs or constellations of UAVs to provide interim coverage could provide for the continuation of ISR activities while other actions to replace space systems are underway. In some circumstances, aerostatic balloons or other lighter than air craft could be appropriate. Development of reliable over-the-horizon ionospheric backscatter radar may also be an alternative. Lunar basing of ISR systems, provided the appropriate international agreements are modified/respected, may provide an unassailable high ground though the coverage allowed by a lunar orbit would be limited.

Subterranean/Magnetic Communications (SMAC) is an interesting area of research that could provide a reliable alternative to space-based communications systems. Theoretically, waves from ground penetrating radar could be used to pass information through the earth rather than having to go around it. This is at a very low Technology Readiness Level and would suffer likely from low bandwidth problems. Cognitive radio networks may have ability to reconfigure space linkages to other available networks to avoid interference inhibiting communications between space and space-ground elements. Similarly, developing autonomous and automatic paradigms for distributed cognitive processing and autonomic computing may allow systems to seek out new connections and work-arounds to continue with its tasks within dynamic environments.

The development of an accurate and continuously updated library of global geometric information could provide an alternative for some aspects of real-time space information. This could be especially relevant to targeting and navigation tasks. This capability, which could be described as ‘Google Earth on steroids’, would require development of enabling technologies in the areas of video storage and retrieval, holographic presentation and artificial intelligence.

Of course, the tried and true practices of the past will still work particularly in the area of navigation. Training may be a key element in any program to retain the ability to operate without the support of space systems. Backwards compatibility to pre-GPS generational equipment may be a non-R&T alternative. The protection of conventionally vulnerable ground segments of space systems is another important element of maintaining access to space-derived information.

4.2.13 – Capable of acting in dynamic 'value chains' with a variety of potential partners

In a business context, value chain models see a firm as a series or chain of basic activities that add a margin of value to a firm's products or services. Value chain analysis highlight specific activities where strategic advantage can be achieved through some form of partnership. These critical points create value by leverages off the core competence of partners or stakeholders in process. At a higher level, increased standardisation/interoperability between stakeholders and access to information systems will allow for the creation of a value web. This can be supported by consortia, symposia and knowledge management to drive higher levels of common understanding and to coordinate activities. These types of relationship building activities also facilitate benchmarking of best industry practices.

The Alliance will in all likelihood be involved in operations will a large number of stakeholders. The ability to assess the value that each stakeholder brings to the table and to make the best use of this value will be fundamental to success in the future. This analysis will be necessary within an environment that has changed from a paradigm of distinct phase – transition from peace to crisis to stability and back to peace – to one of persistent crisis or movement into crisis in different geographic areas. Depending on the evolution of an operation, relationships and contributions may dynamically shift over time. Stakeholders will include Nations, international organisations, other government departments, non-governmental organisations, non-state actors, private companies and others depending on the theatre of operations. The large number of possible stakeholders increases the importance of pre-deployment planning, socialisation and work-ups to increase the overall efficacy of operations.

This capability area also raises issues related to the dissemination and sharing of information and the involvement of stakeholders other than the military in the operational planning process. Developments in information exchange gateways, tailorable firewalls, information tagging and multi-level security will enable the building of a value web and the analysis of the value chain for appropriate contributions. Social networking technologies will continue to improve and may provide a mechanism for access a wide array of subject matter expertise and 'crowd sourcing'. Advances in decision support software, gaming to support course of action analysis, system-of-systems analysis and organisational theory will be enablers to value chain analysis.

1.1.6 – Capable of shaping the 'home front' in the grey zone between peace and conflict

Recent research focuses on:

- Getting in the head of opponents;
- Crafting effective propaganda and disinformation campaigns; and
- Engaging in social/memetics engineering endeavours.

1.3.3 – Capable of generating coherent and integrated policy options

It will be important in generating policy options to be able to design metrics that measure progress. There are four main methods for capturing the data required to assess measures of success – content analysis, expert knowledge, and quantitative data and survey/polling data. Technologies related to these areas will improve the development of policy options.

As B.H. Liddell Hart stated, "strategy depends for success, first and foremost, on a sound calculation and coordination of the end and the means". Policy option also hinges on this critical first-step – determination of the end-state. Uncoordinated and unfocused strategies can result from the difficulty connecting the desired ends with the necessary means required to achieve those ends. The real challenge to democracies is determining a method by which long-term strategic vision is supported by a genuine commitment of resources required to achieve it. Policymakers also require tools that identify problems early if they are to be successful in mobilizing resources and reaching consensus at inter-agency and international levels regarding the appropriate actions to take to prevent the emergence of a full scale crisis.

The development of policy options should emphasise independent thinking, challenging the thinking inside the organization, incorporating alternative perspectives in an attempt to eliminate cultural and ethnocentric bias, and a focus on fully exploring alternatives. Coordination is required between multiple agencies to develop integrated plans. They also require an analytical infrastructure that accounts for multiple competing models of political and social behaviour and the balancing of political objectives in order to devise strategies that achieve a balance between near-term and long-term objectives, and political, economic, military and social goals.

The application of multiple, competing models in analytical processes also assists users in confronting uncertainties by preventing decision-makers from developing plans based on the output of a single model or theory. There is a strong motivation for studying social dynamics and representing societies in a non-deterministic fashion, where non-structural features such as chance, contingency and agency play important roles in behaviour and outcomes.

Testing model sensitivity to deviation in parameters provides insights into the implications of unknowns and what is fundamentally knowable or unknowable about the policy options and their impact on conflict. Robustness of policy options across possible outcomes hedges against unknowns while building in room adaptability as time passes and more information becomes available.

Red teaming of policy options will test their effectiveness across a range of possible scenarios. Red teaming can mean threat emulation, also known as “role-playing the adversary”. Another common meaning is conducting a vulnerability assessment of a process or system design to determine its weaknesses. Finally, red teaming can mean using analytical techniques in order to improve intelligence estimates and intelligence synchronization, common in the defence and intelligence agencies.

Possible areas for research – cellular automata, ARMIA statistical models, Bing models, Massive Multi-player Online Games (MMOG), crowd sourcing. Research in layered social network analysis as applied to non-cooperative networks should be considered.

4.1.8 – Capable to assess and implement the structures and processes for planning/decision-making/activity coordination/feedback across the various actors in a comprehensive approach

One aspect of working in a coalition headquarters is doing collaborative planning, where the group needs to understand what they as a group have been told to do (i.e., Commander’s Intent) and what their part in the task is. Different cultures have different tacit knowledge, and the challenge facing multi-national teams is that of understanding each other’s intended meaning. Application of sense-making theory is helpful to multi-cultural HQs.

Predictive computer simulation can also help to understand the cognitive limitations associated with sequential decision-making with uncertainty within the context of a comprehensive approach.

A number of different types of models/analyses can be developed to assist with decision support. These include high fidelity models of individuals and groups (adversary as well as allies’ and neutral’s) which capture intent, motivations, objectives, goals and strategies. These models may describe how participants will behave under different conditions and provide a capability to anticipate realistic and unexpected behaviours.

System-of-systems modelling wherein modelling of adversary, self and neutrals as complex adaptive systems allow synchronization of actions with effects. This allows the identification of how to stress that system to achieve the campaign goals. This methodology allows for the development of an understanding of the multi-dimensional, interdependent nature of the models from strategic to tactical to support COA development that links kinetic and non-kinetic actions to direct, indirect, cumulative, cascading and unintended effects taking into account the temporal domain.

COA/scenario generation provides the capability to rapidly generate multiple blue COAs (with branches and sequels for foreseeable contingencies) from simultaneous data feeds, both stored and real time. This allows for the development of the ability to produce COAs for multiple simulation environments and to produce suitable, feasible, acceptable, distinguishable and complete COAs across strategic to tactical dimensions. This methodology accounts for emergent adversary behaviour representing the sequential action/reaction/counteraction nature of operations.

COA analysis involves the simulation of kinetic and non-kinetic actions that achieve direct, indirect, complex, cascading and unintended effects, taking into account the temporal domain. This increases the level of understanding of interdependencies of our systems with the adversary systems and the trigger events (what triggers new COAs, spawns COAs and what kills bad COAs). It also allows for the identifying of tipping points, critical decision points, and critical scenario vulnerabilities.

COA comparison is an analytical means of comparing dissimilar simulated COAs against predetermined criteria. This requires the development of metrics and approaches to rank the relative merit of COAs, accounting for causal relationships and dependencies.

This allows for the visualization of uncertainty/risk/assumptions associated with COAs and identifying COAs that are robust against assumptions.

12.1.5 – Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment

> *Everything in war is simple, but the simplest thing is difficult. The difficulties accumulate and end by producing a kind of friction that is inconceivable unless one has experienced war.*
>
> – Clausewitz, On War

Future SSTR operations may be conducted within the framework of an alliance or coalition, whether those operations are prior to, during, or at the conclusion of the “dominate” phase of a major operation or campaign. As such, there is greater opportunity for synergy and unified action and a higher probability of more rapidly and efficiently reaching the desired end-state if potential partner Nations have a direct impact on *planning* the SSTR operations from their inception and well *before* the crisis erupts.

Training must emphasize the speed with which these types of plans must be drawn up, as that is likely to be vital in an actual crisis … planning systems must increasingly adapt rapidly to changing situations with forces tailored to meet contingencies.

Complex, multi-ethnic environments will require coordination as a potential force multiplier with inter-agency. This will require in-depth area knowledge, language skills and adaptive leaders. It has become increasingly evident that quantifying the human terrain will be required. This will necessitate a multi-disciplinary approach enabled by technology.

System dynamics can allow analysis of complex systems from a cause-and-effect perspective. It takes into account the feedback structure as well as the dynamic implications and non-linearity in the system.

Chaos theory provides a method of analysis for complex, non-linear systems. Current strategic planning paradigms seek to simplify complex issues, often failing to recognize the complex interactions upon which these issues hinge. For extremely complex systems, such as human society, detailed models are elusive. Chaos theory allows us to predict outcomes, and therefore potential solutions, without a detailed model.

Wars of tomorrow – like those of today – will require tight integration of fires and manoeuvre at close quarters to exploit tomorrow's technology.

16.3.1 – Capable of conducting civil-military cooperation in an inter-agency environment

Within a typical humanitarian operation, a small number of NGOs do about 95% of the work. NGOs are frequently on the ground well before the military and will probably remain long after the military is gone. These organisations are facts on the ground and cannot be ignored. To achieve unity of effort, collaboration and coordination between NGOs and the military must take place. The military cannot solve humanitarian problems on their own.

The number of actors and variety of factors involved in a complex contingency make it impossible to develop a comprehensive model that can be applied to the NGO-military relationship. NGOs are not homogeneous, each brings strengthens, agendas and institutional cultures to the table. Generally, cooperation between IOs, NGOs, military and other agencies and entities acting in future operations is not about technology, but rather about the good (political) will and endurance.

During operations, communications interfaces can take three forms:

1) Meetings;
2) Single Channel Radio (SCR) communications; and
3) Host Nation infrastructure use.

As future humanitarian assistance and disaster relief missions will require military forces to integrate with NGOs. Voice and data communications will critical at all levels, but will likely be most challenging at the tactical level. Modern cellular systems may provide the necessary flexibility. Various web-enabled systems supported by future satellite systems (e.g., Iridium) may support operations.

Given the common themes and existent systems, the military and NGOs must explore current and developing technologies that will enhance integration. This exploration must be a joint effort. Commercial-off-the-shelf radio systems may provide another option but will likely have to be procured by the military to ensure a common operating environment.

Negotiation training/theory will be a rich area of research for civil-military cooperation.

16.3.3 – Capable of formulating and executing shared and realistic actions

Gathered with other planning discipline capabilities.

16.1.7 – Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa

Gathered with other planning discipline capabilities.

2.1.2 – Capable of assessing the real cost/benefit balance of contracting versus retaining in-house

The utilization of military contractors is global in scope and activity. Outsourcing is the transfer of a support function from a traditionally in-house organization to an outside service provider. The primary goal is to provide the same function with greater quality at less cost. Thus, the workload shifts but no government assets are transferred to the private sector. Most notably, the vendor retains a degree of flexibility and is free to utilize new technologies and business practices to improve service delivery and/or reduce support costs. Of particular distinction is that the government retains responsibility for not only funding, but the standard of service as well. Proponents embrace the idea that comparative advantage and competition maximize efficiency and effectiveness, and cite benefits such as improved service at a lower cost, increased efficiency, greater flexibility, and more rapid responsiveness to changing requirements. At the same time, the contracting process can be complex, time consuming and costly.

The relative direct cost advantage of contractors can vary, and may diminish or disappear altogether, depending on the circumstances and contract conditions. To be sure, countless studies have shown that privatization can create cost savings within both private and public sectors. Yet contracting for services in a contingency environment is a sharp contrast when compared to contracting for laundry services or landscaping. In other words, one should not simply assume that privatization saves money. Some analysts contend that the total costs of private security contracts have been underestimated because they do not include the subsidy that governments in effect provide contracting companies, including when former soldiers, trained at taxpayer expense, are employed. Whereas private firms offer incentives which are maximized in competitive markets, some have argued that public agencies are better at ensuring a degree of loyalty and trust to the Nation state.

Theoretically, the case for privatization is strong if private-sector production of a given level of output is more efficient and more innovative. Another key aspect to privatization is flexibility. The reason that outsourcing sometimes saves money is that it inspires new ideas about how to deliver a service that require fewer people or different materials. A comprehensive statement of work and early contractor involvement can maximize value.

Much of the current debate surrounding military outsourcing often ignores the transactional complexity inherent in contracting arrangements. Transaction Cost Economics (TCE) yields key insights in this area. Typical transaction costs faced by organizations when dealing with outside suppliers include source selection, periodic competition and renegotiation, contract management, monitoring performance, up-front investments, asymmetric information, contract uncertainty, and the existence of layers of sub-contracts which indicates some degree of inefficiency.

Other important costs relate to the “middleman” argument. Typically there are several layers of contracts and sub-contracts. While this provides the government an advantage by shifting some risk to a large prime contractor it can also offset efficiency gains. Accompanying each layer are profit margins for each contractor – potentially leading to higher costs to the government. As the external environment has grown more uncertain, contractors are spending a greater proportion of their operating costs on insurance. Therefore, the government must provide an incentive for the contractors to assume risk. Contractors will demand a greater risk premium the greater the uncertainty.

It is important to note that these economic arguments provide only a theoretical basis on why one should expect efficiency savings. In weighing the benefits of privatization and outsourcing, comparisons often involve an ideal norm and an existing institutional arrangement which is imperfect. For example, private markets often fail to be perfectly competitive and government can also compare favorably for organizing certain tasks. Ultimately, therefore, a comparison must be made between two imperfect modes of organization. Moreover, the competitiveness of these private markets is a precursor towards achieving cost savings and most would agree that such competition is crucial to the make or buy decision. After major contract awards, however, firms may be able to exercise a degree of market power.

Because contractors need not make long-term commitments to their employees, they are in a better position to "surge" to meet a short-term demand for workers and then rapidly downsize later. Contractors can also recruit internationally, which means they have access to a broader labour force which may result in significantly lower labour costs.

Private contractors can incur much lower costs by using local hires extensively, as they do not have to transport them, house or feed them. Perhaps the most important capability contractors bring to the table is adaptability. Most contractors are able to tailor themselves for the specific mission requirements, and do this rapidly, with little overhead or massive support structures.

2.3.8 – Capable of establishing and maintaining liaison relationships with potential service providers/partners prior to commencement of operations

Is this a yes/no proposition rather than an area that can be supported by technology? It is a policy choice to enter into relationships with potential service providers or partners prior to engaging in operations necessitating a contracted relationship.

5.1.3 – Capable of defining unambiguous Rules Of Engagement (ROEs)

This is a policy issue that will need to be addressed as it is brought on by the proliferation of robotic technology within the engagement space. The Body of International Law related to most areas is rarely anticipatory and it will greatly lag events on the field.

There are valid arguments on both sides on the use of autonomous robotic weapons systems. On one side, the argument is made that autonomous systems can be ethical – the ability to act conservatively, the eventual development of and use of a broad range of robotic sensors better equipped for battlefield observations than human sensory abilities, designed without emotions, integration of more information from wider range of sources prior to execution of decision-making. Autonomous weapons offer enhanced accountability through the capability of post-mortem analysis by keeping a detailed record of the decision logic that led to the engagement, a detailed transcript of the engagement, and a detailed battle damage assessment after engagement. Autonomous systems can preserve the legitimacy of the conflict because use of force is constrained by a rigid set of heuristics pre-programmed to comply with the Laws of Armed Conflict and ROE.

While on the other side, arguments against using autonomous robots include establishing responsibility; that the threshold of entry into warfare may be lowered; and that it may be too hard for robots to discriminate. Who is responsible if AW makes a mistake? The Commander who ordered the deployment of AW, the soldier who deployed it or the software programmer who wrote the logic code?

Venn diagram of Law – Policy – Technology describes the necessity to develop policy and law as technology progresses.

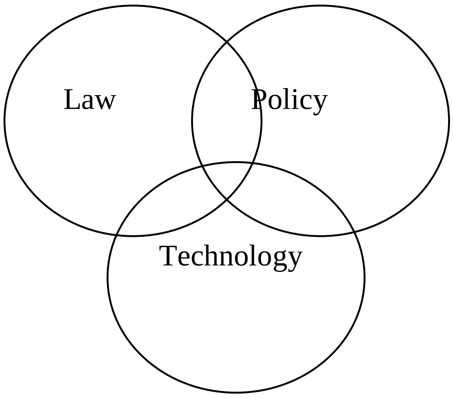

Figure F-1: The Law – Policy – Technology Venn Diagram.

6.3.5 – Capable of developing flexible and adaptive leaders

No degree of technological development or scientific calculation will overcome the human dimension of war. Changing the framework, structure, and processes in and by which a new generation of leaders are developed is a critical component of the current military cultural transformation. The leaders we are creating must be able to learn and adapt in ambiguous situations in a constantly evolving environment. The primary hindrances to this development have been a zero-defects mentality, micromanagement and misuse of the word ‘risk’.

A holistic continuum integrating training, education and professional development establishes the true capacity for an adaptive leader to succeed and make reliable decisions in complex and chaotic environments. This includes allowing leaders to grow and develop trust experience. This experience can be gained through extensive use of simulation, scenario-driven war games and experiments, and training exercises that challenge leaders will reduce the tendency to learn “on the job” in actual combat operations. This should include simulation of moral/ethical questions.

Senior leaders will need to allow space, so subordinates can experiment within the bounds of intent based orders and plans, while taking calculated risks and accepting the possibility those less experienced subordinates will make mistakes. Leaders must reinforce the requirement for self-learning through professional reading and professional military education.

One body of leadership research involves learning how tacit knowledge contributes to the effectiveness of leaders. Tacit knowledge is informal knowledge accrued through experience gained during operational assignments and is related to an individual’s ability to solve problems. – sharing of tacit knowledge. Improved problem-solving directly supports the goal of growing adaptive leaders.

Complexity theory can be applied to developing adaptive leaders. Complexity theory is the study of both natural and social complex systems in which order and coherence emerge as a outcome of the interaction of multiple entities (whether they be proteins, cells, individuals, organizations, or societies). Although a conventional view of organizations and other social systems attempt to avoid the instability and fluctuations of ‘far-from-equilibrium’ systems, stable systems cannot be effectively adaptable because they do not allow ‘choices’ in order for the system to sufficiently adapt to the environment, rather they are ‘guided’ to move back and forth much like a pendulum between the mean of a limited number of alternative behaviours. However, systems close to chaos are those that appear to have the greatest capacity to coordinate complex activities and to evolve in both the natural and social worlds. Teaching a rigid doctrine of leadership and operations rather than a more flexible version may result in the former rather than the later.

Organizational Learning – a learning organization is an organization skilled at creating, acquiring and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights. Development of the capacity for learning at the organizational level will translate into adaptive leaders at the tactical level.

Opponent models of behaviour must become more dynamic and challenge trainees with adaptive threats consistent with those increasingly encountered by the military. Including the effects of motivations, capabilities and weaknesses of adversaries within these models is still extremely difficult. A significant limitation of current threat simulation models is their lack of dynamic asymmetric opponent behaviours reflecting recent and current adversary tactics and methods. Frameworks must be developed that provide a means for adversary models to analyze the tactical situation during execution, and adapt their behaviours and tactics accordingly. Hidden Markov Models provide a method for incorporating uncertainty into models.

According to Prensky, a unique feature of future learners is that they may choose to pay attention in bursts rather than continuously. He states that they "Tune in just enough to get the gist and be sure it makes sense". Numerous sources acknowledge this propensity for millennials to pay attention in "twitch speed" bursts while multi-tasking, and bricolaging (or piecing together information). This has in turn led to a concern that the millennials' thinking may be characterized by short attention spans and a lack of reflection. If true, the latter characterization would be especially troubling given that reflective thought contributes to adaptive thinking and adaptive thinking is a critical future soldier competency. However, others have suggested that the reported short attention spans and lack of reflection among millennials merely signify that these learners possess an invaluable attribute – the ability to evaluate information rapidly. Puchta and others point out that the most valuable skill in the twenty-first century probably won't be attention span, but rather the ability to multi-task – another characteristic that may be more common among millennials.

Research areas – Hidden Markov models and cognitive modelling.

7.3.4 – Capable of adapting organizational structures to reflect changing circumstances and evolving objectives

We haven't got the money, so we've got to think.

Physicist Ernest Rutherford

An organization's ability to reconfigure quickly to exploit an opportunity, whilst retaining a robust decision-making framework that ensures overall clarity is at the heart of effective operations.

Almost all force structure analyses are now built around the use of formal computer models whose ability to represent dismounted warfare against dispersed, covered, concealed targets in complex terrain is limited.

The growing challenges of organizational and technological complexities require the development of new organizational concepts. Any organization designed to manage conflict must be thoughtfully constructed to encourage unity of effort. Optimally, it should be incorporated into operational planning at the earliest stages and it must be constructed in a manner that allows for appropriate expansion or restructuring as the environment changes. The organization also must be realistic in its demand for resources which requires a holistic inter-agency assessment based on the contemporary operating environment. Finally, all post-conflict transition organizations must be capable of managing the five essential tasks for reconstruction and stabilization:

1) Security;

2) Governance;
3) Humanitarian assistance and social well-being;
4) Economics and infrastructure; and
5) Justice and reconciliation.

These organizations should emphasize simplicity, responsiveness, flexibility, sustainability, and efficiency to achieve maximum success.

Given the historically predictable budgetary future, the military must be willing and ready to change its current capability portfolio and programming to fulfil the shift in strategy. This change must be done in a timely fashion and in a manner that adapts efficiently and effectively balancing capability, capacity and human capital. In a perfect world, one would target capabilities and capacities to field a minimal, basic or enhanced program based on the threat, end-state and risk with known fiscal limitations in a finite strategic framework. Identifying what programs need an enhanced capability is an imperative. These programs need to mitigate critical risks and should be funded with depth, reach and emphasis, but not at the total expense of the programs that are identified as needing basic or minimal capabilities and capacities. These less-crucial capabilities might not be the key to security today, but could be the programs that shift to an enhanced emphasis should the winds of change come upon us.

Providing timely, clear direction based on the best available information is at the heart of both setting and achieving an organization's aims. Indeed, the ability to consistently make the right decision at the right time can be a significant competitive advantage. Although perhaps an obvious statement, it is important to remember that the operational implementation of a strategy requires a decision-maker to guide the application of people and materials to a process, through the collection, analysis and use of information. As information sources and volumes continue to multiply, the certainty that a decision is being based upon the right and best available information decreases – the paradox of uncertainty caused by too much information. That may or may not be relevant to any given decision, resulting in an increased uncertainty as to the sound footing of any decision.

The concept of multi-criteria decision analysis offers a framework for surfacing and balancing the various perspectives and requirements of each stakeholder, and to consider which information is of most importance in agreeing a course of action.

Mission command, or as it has been known in its German name *Auftragstaktik*, is a decentralized leadership and command philosophy that demands and enables decision and action in every echelon of command where there is an intimate knowledge of the battlefield situation. It calls for subordinates to exploit opportunities by being empowered to use their initiative and judgment, as long as their decisions serve the higher objective communicated to them prior to the mission, which is referred to as *intent*. It is based on the belief in the ability of an individual to act wisely and creatively in order to solve a problem without having to resort to higher authority.

Mission command aims to avoid the drawbacks of centralized systems, which suffer frequently from a lack of flexibility and responsiveness. It also helps avoid the usual shortcomings of decentralized systems, that is, the lack of coordination and control.

Through the use of the higher *intent* as a coordination mechanism, it goes beyond simple decision delegation and empowers subordinates; it provides a flexible framework that allows the exploitation of opportunities while maintaining the overall purpose of a military operation. A key element in the success of this approach is the articulation and communication of the Commander's *intent*.

However, to be able to fully exploit these advantages, new patterns of behaviour and forms of organizations are required. The new focus is on access and speed of information, sharing information and collaboration, therefore a radical transition from the traditional top down hierarchal organization is required. Instead, this paradigm would best suit flat, networked organizations.

According to theory, these organizations should adhere to a number of principles in order to fully exploit the information advantage. Each advantage is dependent upon a few such guiding principles:

- High quality shared awareness is achieved through the application of a collaborative network of networks;
- Dynamic self-synchronization and adaptivity sustained by skipping the traditional hierarchy when change is necessary;
- Elimination of organizational boundaries and create new processes to achieve rapid effect; and
- Rapid speed.

Above all, the overarching principle should be the ability to empower individuals at the edge of organization, where they have the most interaction with the environment and can quickly make a resounding impact on this environment. This involves expanding access to information and the elimination of unnecessary constraints to get it. It implies enhanced peer to peer interactions on all levels of the organizations.

Organizational Learning – a learning organization is an organization skilled at creating, acquiring and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights. Development of the capacity for learning at the organizational level will translate into adaptive leaders at the tactical level.

Like the human body, an organization is a complex adaptive system. Everything in it is related to everything else. Chains of causality are not linear.

8.1.2 – Capable of gathering, analyzing and disseminating lessons learned in a timely fashion

Same processes as associated with holistic KB would be useful here.

9.2.2 – Capable of empowering society/local communities to mitigate against the risks associated with the proliferation of duel-use technology

No data.

10.1.3 – Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment

The first wave of revolution in military logistics focuses on exploiting improvements in automation, communications, business practices, and reshaping command and control relationships to provide better unity of command and reduce logistics footprint.

One of the emerging technologies to support transforming logistics is telepresence which could allow the performance of certain logistics functions in a more adaptive manner without the presence of humans thus reducing logistics footprint and deployment requirements. This technology could be applied to medical procedures and extended to mechanics conducting maintenance on vehicles. This requires the transmission of sensory information from the remote site through a communications link to the home site. The reduction of home and remote site latency (time delays) will be important to increase the feel of fidelity. Telepresence will be enabled by visual technologies – head mounted stereoscopic devices to allow 3D viewing, auditory technologies to provide fidelity of sound, tactile technologies – haptic devices that transmit feeling to hands, and robots that can action the remote directions.

Another of the new processes under consideration for transforming logistics is designing systems and platforms with modular components to simplify replacement and sustainment. Modular systems would permit simplification of the current maintenance system. Characterized as "replace forward and repair rear," field units would remove and replace modular components if possible or release the platform for evacuation and repair by a unit in the rear.

New distribution systems would facilitate rapid throughput and follow-on sustainment.

The use of configured loads for specific consumers and for specific operations, when combined with an intelligent load-handling system for rapid loading and unloading of aircraft and ships, would reduce materiel handling time and speed up delivery of the configured loads to the designated units.

11.1.1 – Capable of researching and executing strategies that mitigate the need for large numbers of forces

Many technology trends point to more technical solutions and less human-centric solutions. Among these are:

- By optimizing techniques – both capacity and capability through operations research.
- Capacity enhancement – better operational awareness and folding robots and the human into the overall system can better reduce per human/soldier footprint and enhance recruitment and retention.
- Capability enhancement – delisting mil specifications to enhance use of off-the-shelf equipment.

Improved and multi-disciplinary training can lead to working with smaller force numbers.

Other ways to lower the requirement for larger numbers of human would be:

- Human performance enhancement – super humans – through biochemical or biomechanical enhancements or prosthetic devices.
- Building emotional resiliency into military ethos (lessening the impact of deployment).
- Improved and embedded training vs. immersive training, i.e., down loading knowledge (The Matrix); reducing the rotational cycle (doing more with what one has).
- Speeding up reintegration and retraining.

Some of the above pose a societal challenge – military-civil society separation vs. integration. This particular aspect could be mitigated by changing the educational paradigm – everyone participates in the military in lieu of education.

Units must be able to be disaggregated to operate in small units and then be able to re-aggregate if required to operate against larger formed units.

12.2.6 – Capable of acting without access to cyberspace

No data.

16.3.4 – Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements

There is a requirement to explore new methodologies to exploit bandwidth and the electro-magnetic spectrum. This may be well served by research in the area of data compression. Pushing data processing to the lowest possible level to reduce demand for bandwidth would assist in this purpose – only processed data of value to higher levels would be transmitted over networks.

As with most government/military procurement, fielded communications systems lag technical improvements available on the commercial market.

The movement from the Graphical User Interface (GUI) that allows user to interact with electronic devices to the Natural User Interface (NUI) will allow better applications in the future.

Research in the areas of detection and tracking algorithms would provide best potential for significant improvement. Another area of great potential is Automatic Target Recognition (ATR) and Ground Motion Target Indication (GMTI).

16.3.8 – Capable of undertaking in-depth foresight analysis to develop models of the future security environment

Without continued and more sophisticated “horizon scanning,” there is near-certainty that the next compelling *defence-relevant* challenge will be a “strategic shock”.

17.1.3 – Capable of designing effective media strategies

Media will continue to be a significant factor in the success of any operation. Though the Media will keep their own independence – they will cooperate with the military as with other resources.

Development of internet – anybody can be a journalist today.

Basic way of influencing the public opinion is to assure the provision of information through trained members of the Armed Forces (to train all members, even at tactical level, on what kind of information the soldiers can provide to the media and what is restricted).

Media are a source of information for the enemy. As well, the media of the adversary will always influence operations – INFOOPS, PSYOPS. There may be a growing role of disinformation.

17.3.2 – Capable of exploiting information space for dis-informing opponents

In the 21st century, the operational level Commander conducting operations must clearly understand the influence the media has on the success of operations. Media influences on world public opinion can now change the traditional model of warfare described by Clausewitz’s trinity. World public opinion, influenced by the media, is now a fourth factor in influencing war modifying the trinity into a diamond (the military, the government, the people and the media). Therefore, operational level Commanders must address the media in their planning and operations.

Why, in today’s information world, where the world has transformed into a global village, are the societies more vulnerable to manipulation? Worldwide media reach; incessant news cycle and 24/7 news reporting; real-time Information; inexpensive and easy news creation/acquisition of images; and the Internet.

Perception, the process of forming images of the world, can be thought of as involving two sub-processes. Sensory data is first acquired, then [it is] organized and analyzed to form a coherent, comprehensive picture. Thus, misperception of the world can arise either from incorrect data, or from mal-processing of correct data.

Perception management can be defined as actions taken to convey and/or deny selected information and indicators to foreign audiences to influence their emotions, motives, and objective reasoning as well as to intelligence systems and leaders at all levels to influence official estimates, ultimately resulting in foreign behaviours and official actions favorable to the originator's objectives. In various ways, perception management combines truth projection, operations security, cover and deception, and psychological operations.

Perception Management is, in fact, influence operations designed to persuade adversaries into a favored course of action. This may be achieved through the threat and/or use of force and/or political and international pressure. The use of force aims to convince adversaries, or third parties, to act in accordance with self/national interests and goals.

When designing a Perception Management effort, certain deception principles, or tenets, apply:

- Manipulating pre-existing belief;
- Conditioning;
- Utilization of truth;
- Feedback;
- Second order effects; and
- Overall design.

PM seeks the following three major objectives to:

1) Build and preserve public opinion support (at home and abroad) and to gain and maintain legitimacy;
2) Communicate desired intent and objectives to hostile and/or third parties to establish a high degree of credibility so they fully understand the consequences of their actions; and
3) Influence the attitudes and behaviours of the local populations so they act in accordance with one's own objectives.

Perception Management includes four steps:

1) Getting the target's attention;
2) Presenting relevant information to hold the target's attention;
3) Portraying the information in a way consistent with the target's memory or experiences; and
4) Repeatedly communicating the information to remain congruent and to avoid the ploy from being discovered by the target.

In addition to the above, it is paramount that the information should be timely.

Within domestic and non-adversary audiences, true legitimacy is the perception of an appropriate legal, moral, and ethical basis combined often with a belief in the necessity of responding militarily. Legitimacy stems from the mandate, the respect for the law of war, and regard for humanitarian principles. Legitimacy is a key pillar because it sustains popular support and will to fight, without which democracies cannot sustain military action.

Threads that interweave through many capability areas

As would be expected of any survey of capability requirements and relevant technologies that could enable solutions for those requirements, there are technologies that are relevant to several areas. The development of these technologies would seem to be a higher priority than others as they would enable broader solution work. These technologies would appear on the left side of a Pareto diagram representing the important few amongst the many.

All areas related to knowledge management and sharing provide a foundation for many other capabilities. Agent-based ontology and holonic systems for gathering and categorizing heterogeneous information from disparate databases/sources, multi-level security to allow dissemination of the knowledge, advanced encryption, real-time user verification, reliable information tagging and tailorable firewalls are all imperative to the development of a holistic knowledge base. Appropriate knowledge representation will facilitate decision-making. These will all be supported by artificial intelligence. Providing access to this knowledge base down to the unit level for real-time reachback will support operations.

The knowledge base will be supported by persistent sensors that can provide hyperspectral information. Miniaturisation of components and development of more efficient power sources will support the deployment of persistent sensors that are difficult to detect.

Social networking and massive multi-player gaming being developed as commercial ventures will certainly provide the basis for some military applications in the future. Decision support tools based on advanced systems such as agent-based modelling and systems dynamics will provide a sounder analytical basis for improved decision-making in dynamic environments. Research into complex adaptive systems and their applicability to Alliance operations will also be an important enabler.

Lastly, red teaming, common lexicon and procedures, doctrine, organisation and other non-technical subjects are rich areas for examination. Interoperability will be critical to the functioning of multi-stakeholder teams in complex environments. Standardisation will continue to be a critical Alliance objective.

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Annex G – THE JO 2030 MULTI-NATIONAL EXERCISE

The JO 2030 Study effort concluded with a 2½ day Multi-National Exercise (MNE) held at the offices of the Western European Union in Paris, 8 – 10 September 2009. In attendance were 25 experts in various fields and from 11 different NATO Nations and 4 PfP Nations joined by 14 Members of the JO 2030 Study Group and 4 other members representing the NATO Research and Technology Agency. Collectively and collaboratively they lent their insights and expertise in reviewing and identifying Technology Focus Areas that could potentially lead to or produce solutions of interest and benefit to the List One TICs. This Annex presents the Agenda from the MNE and Table G-1, a table of the event participants.

AGENDA

SAS-066
Joint Operations 2030
Multi National Exercise
8 – 10 September 2009
Offices of the Assembly of Western European Union,
43 President Wilson Ave, Paris, France

Tuesday, 8 September 2009

SESSION 0 – REGISTRATION

13:00 Arrive and Sign In

PLENARY 1 – WELCOME AND STUDY INTRODUCTION

14:00 Welcome to the Assembly of the WEU
Mr. Gilles Combarieu, WEU Deputy Secretary General

14:10 Welcome to the NATO RTO Joint Operation 2030 MNE
MGen. Albert Husniaux, NATO RTA Director
and
Mr. Paul Massel, Study Leader

14:20 A Perspective on the Future of Defence
Mr. Stephan de Speigeleire

14:40 Introduction to the Joint Operations 2030 Study
Mr. Paul Massel, Study Leader

14:50 J O 2030 – How We Did Defence Planning for the Future
Mr. Frank Bekkers

15:00 JO 2030 –Generation of the Themes
Mr. Mark Tocher

15:10 JO 2030 – Themes to Capabilities
Mr. Simon Purton

15:20	JO 2030 – Searching for Solutions LtCol. Jens Hartman
15:30	JO 2030 – TICETs Mr. Paul Massel, Study Leader
15:50	Plan and Objectives for this MNE Mr. Paul Massel, Study Leader

SESSION 1 – INITIAL BREAK-OUT AND DISCUSSIONS

16:00	Break
16:30	Meet in Break-out Groups Introductions Review and Discuss Study and MNE Objectives
17:00	Adjourn
19:00	Symposium Dinner (No Host Event) – Place to be confirmed

Wednesday, 9 September 2009

SESSION 2 – BREAK OUT #1 and 2

09:00	Meet in Break-Out Groups and review first set of TICETs
10:15	Break
10:45	Resume and review second set of TICETs
12:00	Lunch – MNE lunch in the Assembly of the WEU

SESSION 3 – BREAK OUT #3 and 4

13:30	Meet in Break-Out Groups and review third set of TICETs
15:00	Break
15:30	Resume and review fourth set of TICETs
17:00	Plenary Session
17:30	Adjourn
19:00	Free Evening

Thursday, 10 September 2009

SESSION 4 – BREAK OUT #5 and 6

09:00	Meet in Break-Out Groups and review fifth set of TICETs

10:15	Break
10:45	Resume and review sixth set of TICETs
12:00	Bottom-up input on Technology Focus Areas
12:30	Lunch – No host in the surrounding area

PLENARY 2 – PLENARY – MNE REVIEW AND CONCLUDE

14:00	Key findings by TICET and Break-Out Group Break-Out Group Facilitators
15:30	Study Self Criticism What was learned and what was missed
16:00	Concluding Remarks Mr. Paul Massel, Study Leader
16:10	End of Multi-National Exercise

Table G-1: Table of Participants at the JO 2030 MNE in Paris France, 8 – 10 September 2009.

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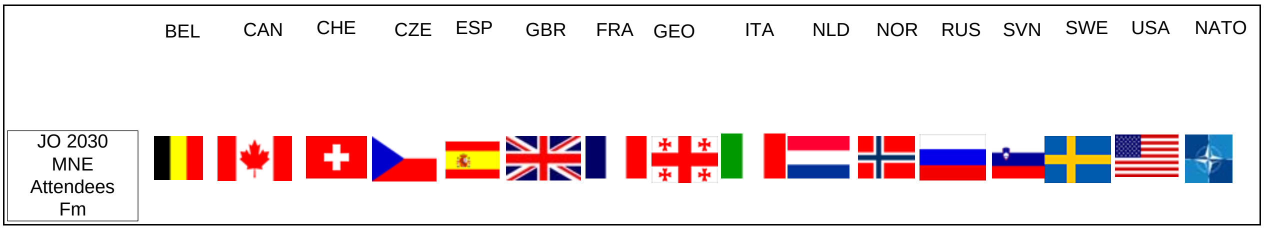

Annex H – THE JO 2030 LIST ONE SET OF TECHNOLOGY FOCUS AREAS

This annex contains the information that documents the origin and contents of the JO 2030 TFA Set. Specifically, Annex H includes:

- The comprehensive set of notes and inputs that are the source material of the JO 2030 TFA Set as gathered from various Solution Solicitation Sessions and the MNE and grouped by the List One Capability list. The inputs to the source material begin with the capability as a title, followed by one or more List One Theme-Issue-Capability descriptions that were with this capability, then by any TFAs or other inputs that were gathered from the Phase IV outreach efforts and the Phase V MNE; and
- Table H-4, the JO 2030 List One Set of TFAs, which is an extraction of the 247 JO 2030 List One TFAs from this source material.

H.1 CAPABLE OF SHAPING THE 'HOME FRONT' IN THE GREY ZONE BETWEEN PEACE AND CONFLICT

H.1.1 Theme-Issue-Capability Description

TIC 1.1.6 – Blurred Distinction between Peace and Conflict

The distinction between peace and conflict will become more blurred over the next decades as forces are used to accomplish traditional and non-traditional military missions in areas where a sustained threat will be present. This will be brought about by the globalization of the threat from terrorists, extreme fundamentalists, trans-national criminals and the weapons proliferation. There will be a shift from the sequential, phased, contiguous operations of the past to more continuous, simultaneous, parallel and distributed operations bringing military forces in contact with civilians, NGOs and indigenous security forces as well as a variety of opposing forces with diverse motives for conducting violent and non-violent actions.

Issue – Peace and Conflict Coexist

In some areas of the world the situation is one where small sporadic conflict is so interwoven with normal life that people continue with their lives in spite of daily danger and regular episodes of conflict. Furthermore, expeditionary operations create the situation where a Nation is at peace at home, but at war (at least in practice if not de jure) abroad. The public needs to be aware of the (supposed) role of the military in the grey area between peace and conflict. Support of (possibly protracted, risky, costly) military activities without 'a war going on' might otherwise be withdrawn easily.

Capable of shaping the 'home front' in the grey zone between peace and conflict.

H.1.2 JO 2030 Phase IV Out Reach Results

S21 – DRDC CORA Strategic Analysts

From Study Leader Notes:

- What is victory and how can it be achieved? It is different in different worlds – see the Balkans.
- Military in a non-military role? Is this achievable and sustainable?
- Crisis and the Western way of war – role of the post-modern State.
- Victory vs. success?
- Is public support the centre of gravity of the success of an operation?
- Anti-terrorism is as much a police function as it is a military function.
- Our understanding of conflict has changed because of different societal and cultural perspectives.
- This depends on how we define end-state – and deal with mission creep and mission evolvement.
- Some discussion on the whole notion of what is war in the post-modern, information age.
- Whither an 'imperial policy'?

Technology Focus Areas

- Conflict studies, underlying drivers.
- Media and perception studies.
- Studies of group and societal influence and behaviour.

H.1.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Today the military takes on numerous and various campaigns that the general public perceives as neither war nor peace. Leads to the need for better understanding of how societies react to both positive and negative information, e.g., why is one death due to IEDs more “newsworthy” than 1000 deaths on our roads?
- The existence of 24/7 news coverage and numerous media platforms leads to the need for advanced understanding of the influence of various mechanisms (TV, radio, Internet, etc.) and how they can best contribute to getting our positive messages out.
- Opposing elements have their own rapid access to the media. One way of countering such potentially negative and inaccurate information is to get our own message across speedily and accurately. This would be assisted by a better understanding of cognitive considerations reflecting society’s interests, motivations, fears and attitudes towards information presented in and by the various media outlets.

Technology Focus Areas

- Socio-cultural cause-effect studies/models.
- Studies of societal dynamics, stability and influencers.
- Macro human, social, cultural behavioural studies/models.
- Public perception issues.
- Cognitive studies (potentially building on ongoing research within the fields of communication technology and marketing strategy).

Solutions

- None identified.

H.2 CAPABLE OF GENERATING COHERENT AND INTEGRATED POLICY OPTIONS

H.2.1 Theme-Issue-Capability Description

TIC 1.3.3 – Blurred Distinction between Peace and Conflict

The distinction between peace and conflict will become more blurred over the next decades as forces are used to accomplish traditional and non-traditional military missions in areas where a sustained threat will be present. This will be brought about by the globalization of the threat from terrorists, extreme fundamentalists, trans-national criminals and the weapons proliferation. There will be a shift from the sequential, phased, contiguous operations of the past to more continuous, simultaneous, parallel and distributed operations bringing military forces in contact with civilians, NGOs and indigenous security forces as well as a variety of opposing forces with diverse motives for conducting violent and non-violent actions.

Issue – Establish a Workable Division of Labour /Collaboration Structure with Other Agencies

Both with other governmental agencies, with NGOs and with private parties (see Theme 2). In various forms of partnerships or customer-contractor relationships. Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate.

Includes issues concerning the role of private contractors vs. the core responsibilities of Armed Forces (as a power instrument of a State). Same for the role of the Armed Forces in national crisis and disaster management vis-à-vis the role of civil authorities and operational services (e.g., first responders).

Capable of generating coherent and integrated policy options.

H.2.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.2.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- This TIC was not reviewed during the MNE.

H.3 CAPABLE OF DEVELOPING, ASSESSING AND IMPLEMENTING STANDARDISED BUSINESS RULES AND PRACTICES AMONG MILITARY, INDUSTRY, NGO, IO AND OTHER ENTITIES

H.3.1 Theme-Issue-Capability Description

TIC 2.1.2 – Standing Arrangements

Increasingly, in order to achieve its political and military objectives, the Alliance will operate within a comprehensive approach that will include a host of non-military supporting/supported organizations. The complementary capabilities of these partners will increase the overall capability of the Alliance to achieve its goals and, thus, must be included in the early planning and execution phases of operations to ensure their coherent application. These organizations will include NGOs, international and regional IOs, and private contractors which are increasingly being used to outsource non-core military capabilities. In order to successfully coordinate lines of development and to integrate these organizations into operations, it will be necessary to consider them within the operational planning process and to develop standing arrangements.

Issue – Understanding Different Business Models

The real cost/benefit balance between contracting out a service vs. retaining in-house capability is difficult to measure and assess. It is also a dynamic balance, to a large extent driven by actual developments difficult to predict in advance.

Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities.

H.3.2 JO 2030 Phase IV Out Reach Results

S19 – Canadian Forces Legal Branch

Notes from Study Leader:

- There are an awful lot of players, OGD, COIN, non-mil, UN – often very hard to build trust with some or many of these agencies.

S24 – DRDC Toronto

Notes from Study Leader:

- How do you build a capability with a contract?

Technology Focus Areas

- Studies on organizational trust and relationship building.
- Organizational motivation.
- Social capital studies.

H.3.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Identify the core competencies that must be kept in-house (e.g., C2).

Technology Focus Areas

- Build better models of outsourcing:
  - How far do we decompose services? If we allow a very high degree of specialisation we can have specialist firms do a very effective and efficient job within their area, but it could become costly to integrate those services back into a complete, functioning system. Where do the trade-offs lie?
  - Based on such models, what do we optimise? Is it just cost, or is it also the total system robustness, trust between actors, etc. What are the trade-offs?
  - Multi-agent modelling is one tool that could be used for this, combined with optimisation techniques.
- Explore reach-back in new areas. Long-distance maintenance, the expert is back home, use remotely controlled robots (or humans) to the repairs in the field.

Solutions

- Improve lessons-learned between Nations. Nations do this differently, what are the pros and cons of the different strategies.

H.4 CAPABLE OF ESTABLISHING AND MAINTAINING COMMUNICATION CHANNELS AND LIAISON RELATIONSHIPS WITH POTENTIAL SERVICE PROVIDERS/PARTNERS PRIOR TO THE COMMENCEMENT OF OPERATIONS

H.4.1 Theme-Issue-Capability Description

TIC 2.3.8 – Standing Arrangements

Increasingly, in order to achieve its political and military objectives, the Alliance will operate within a comprehensive approach that will include a host of non-military supporting/supported organizations. The complementary capabilities of these partners will increase the overall capability of the Alliance to achieve its goals and, thus, must be included in the early planning and execution phases of operations to ensure their coherent application. These organizations will include NGOs, international and regional IOs, and private contractors which are increasingly being used to outsource non-core military capabilities. In order to successfully coordinate lines of development and to integrate these organizations into operations, it will be necessary to consider them within the operational planning process and to develop standing arrangements.

Issue – Establish a Workable Division of Labour / Collaboration Structure with External Service Providers

Both with other force providers (e.g., regional security organisations such as the African Union) and with private parties. In various forms customer-contractor relationships. The interaction between Armed Forces and external service providers within an operational theatre must be integrated and coordinated. Tactical and operational C2, ISR and SA to work with and track those that are linked and not linked to the endeavour.

Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations.

H.4.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.4.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Shared partnerships will likely be pursued more in the future. This highlights the need for protocols for allowing NGOs to access and provide appropriate information.

Technology Focus Areas

- Tactics, techniques and procedures.
- Tool development.
- Multi-level security.

Solutions

- None identified.

H.5 CAPABLE OF BUILDING A COMMON, SHARED HOLISTIC KNOWLEDGE BASE OF THE OPERATIONAL ENVIRONMENT AND IDENTIFYING A POTENTIAL ADVERSARY'S STRENGTHS, VULNERABILITIES AND POTENTIAL BEHAVIOUR

H.5.1 Theme-Issue-Capability Description

NOTE: Of the forty A-List Theme-Issue Capabilities (TICs), there were a total of 6 TICs that were the same capability and they have been combined in this section.

TIC 3.1.6 – Planning Under Deep Uncertainty

In the past, where conditions were relatively certain, Alliance defence and operational planning processes were deliberate and reflected 'strategy as design'. The fluidity and pace of change within the emerging globalised environment will increasingly demand that planning for Alliance operations will be done under conditions of deep uncertainty. Deep uncertainty is present when decision-makers do not know or cannot agree on the current system model of how things fit together, prior probabilities, timing and cost. This will require a new suite of methods and analytical tools to support decision-makers in a 'strategy as process' manner to develop capabilities that are flexible, adaptable and robust.

Issue – Dealing with Intrinsic Uncertainty

Concerns the mindset of people making decisions. Real options approach, buy a stake in a solution and then opt for that solution when needed. Additional Theme-Issues:

- Change the OPP;
- Adaptive leadership Symposium;
- Learning adaptability;
- Invest in training;
- Lessons learned; and
- Breaking of the control paradigm.

Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour.

TIC 7.3.2 – Small Teams Operations

In the future, military operations will increasingly be the domain of small units and teams. This will include variants of small fighting units and multi-disciplinary teams designed to address specific multi-faceted problems where security only forms part of the puzzle. These teams must generally work autonomous, independent operations for considerable periods of time. These teams must be able to shape the 'command intent' to develop solutions based on local conditions. They must be to 'sense and respond' independent of the larger force and adapt accordingly. This will drive modularity and networked requirements.

Issue – Quick Organisational Learning Cycle

Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen out tried-out but proven ineffective strategies and to amplify effective emergent strategies.

Sharing of 'situational understanding' to achieve coherent effects that are realistic in the given situation.

Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour.

TIC 8.3.1 – Strategic Compression

Strategic compression can be defined as the forming of unexpected casual relationships and breaking of expected causal relationships among the tactical, operational and strategic levels of conflict in the political, information, military and economic domains. This is a combination of the 'strategic Corporal' and the 'tactical politician'. This is brought about by the interconnectedness of the globalised environment and the pervasiveness of the 24-hour media cycle supported by almost instantaneous information systems and networks allowing more people access to more information. The coalition nature of most future operations will increase the importance of controlling strategic compression to maintain the coherence/viability of the coalition.

Issue – Morality and Culture in Coalition / Inter-Agency Endeavours

If typical operations become more international and inter-agency (and even with external service providers), with (the need for) cooperation and collaboration pushing down to the tactical level (see, e.g., small team operations), several issues arise. The most fundamental issue might be the need to in make an endeavour succeed with parties that act from quite diverse moral and cultural views.

Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour.

TIC 13.2.3 – Coalition Operations

In the future, no single instrument of power will be able to solve complex crises. Coalitions will be used extensively to conduct all manner of military operations. Members of the coalition will provide various capabilities to the force while accepting differing levels of risk. Coalition operations will highlight areas such as interoperability and common doctrine. The ability to develop a common strategy within a common legal framework will be crucial to the achievement of coalition objectives. This Theme raises issue of interoperability, role specialization, training and sharing of technology.

Issue – Legal Issues and Caveats

Legal issues that deal with coalition operations. Application of laws of armed conflict. Geneva Convention and International Court of Justice. Applies a sense of coalition in a broad sense, not NATO led but with NATO Nation participation.

Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour.

TIC 16.1.5 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the ‘whole-of-government’ or ‘comprehensive’ approach; and
- The need to garner public support for ongoing operations.

Issue – Achieving Campaign Level Surprise

Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by political-military decision-making.

Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour.

TIC 16.3.7 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future ‘mission space’ is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

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- The need to share equitably the burden of risk and cost;
- The incorporation of the ‘whole-of-government’ or ‘comprehensive’ approach; and
- The need to garner public support for ongoing operations.

Issue – Comprehensive Approach

Embedding military capability/efforts in inter-agency endeavours.

Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary’s strengths, vulnerabilities and potential behaviour.

H.5.2 JO 2030 Phase IV Out Reach Results

S1 – Washington

From ACT Notes:

- Care must be taken to ensure that information input into the Knowledge Base (KB) comes from credible sources or is encoded/weighted to include credibility level. The possibility exists for false-fronts to exist that would seek to input false information with hopes of discrediting the Alliance.
- There will be a transition from the preparation phase of building the KB to the maintenance of the KB and action information from the KB during the execution phase.
- Personnel at the tactical level engaged in gathering information should have access to voice stress and gesture analysis in order to assess credibility of local sources. This system must be amended to local tribal customs/nuances. Must be able to identify tribal affiliations of sources and assess against credibility of past contributions.
- A real-time 'lifeguard' accessible through 'reach back' that would give assistance such as translation, access to biometric feedback, information on the credibility of the source. The 'lifeguard' could provide access to behavioural specialists that could assess the situation through real-time audio/video feeds from the field. Provide conduit to KB from assessment of information based upon other data from that or related areas.
- KB must include the key needs/desires of all stakeholders to allow developments of contingency plans to react quickly if mistakes/mishaps do happen to occur.
- Access at some level to the KB will give stakeholders the feeling that they are part of the team.
- A large number of Issue-Capability pairing presented to the group was thought to be immovable political/social/procedural hurdles. Most are common to all Nations and agencies within Nations so would benefit from wider collaboration across Nations.
- Hollywood style productions/gaming could be used to get messages across to the public.
- Top-tier academics may not be the best source for innovative thinkers in areas such as behavioural science, anthropology, etc. Many have an agenda, personal stake in particular perspectives. Many second-tier trained personnel are available that would provide the necessary expertise in the development and maintenance of the KB.
- Many web tools for monitoring web content and the press as well as public opinion are available to undertake gathering of information for the KB.
- The Multi-lateral Interoperability Program (MIP www.mip-site.org) may provide a possible venue to develop standards for the implementation of KB.
- The capability statement should include reference to own forces as well as those of adversaries.
- Real-time strategy games provide a possible construct for development of planning system that consider the 'power/capability level' of forces down to the unit level and then allow any combination to be tested against any scenario.
- How do we capture casual relationships and ensure that they are input into the KB?
- Expert systems developed with massive heuristics could be used to assess the importance of information and the connections between data. Could also be used to assess the level of accessibility of individual participants within the KB.
- Research bots/spiders could be developed to scan/troll the web and other sources for information to be gathered in the KB.

- Nano bots (Dust) developed to be persistent sensors to gather intelligence.
- Question was raised do we need to invest large amounts of time maintain a KB or just the ability and tools to quickly develop the KB when circumstances dictate that it will be required for a particular operation.
- The issue was raised that we may not know what we don't know.
- All information required for the KB may not be in the infosphere or may not be organized for easy automated retrieval.
- 'Youth culture' sites that may contain valuable cultural information may not appear on the horizon of most traditional intelligence agencies.
- The people required to develop the KB may not be those that are presently in positions to do so, i.e., normative business structures do not recognize the needed talents/computer language (geek) to conduct the task.
- Could the internet 'group-mind' be harnessed to conduct research (open sourcing, crowd sourcing)? This could take the form of games to tantalize the group-mind to work diligently to solve complex problems.
- Virtual reality games can be used by adversaries to pass information, intelligence, raise funds, launder money and conduct training/operations rehearsals. Games allow operatives to develop long-term relationships with socially isolated persons that could be developed in agents. Target selection becomes easier as habitual players self-select themselves.
- The cooperation of gaming industry would be required to scan games for illicit activity. Solution may be to develop a commercial enterprise to draw such people to a friendly developed 'sting' game or use 'sting' players within an existing VR game. This could be used to develop the profile of what psycho-social factors are exhibited by the disenfranchised likely to be recruited.
- The rise of 'virtual states' was highlighted as a future concern. Virtual states own no land but provide some aspects of care/defence to the people, e.g., Al Qaeda or Hezbollah.
- Require the capability of conducting network/nodal analysis to develop coherent pictures of networks for KB.
- Require spiders and expert systems as well as 'wetware' that can analyse the content of the net to associate/correlate information as well as the rules and structures for accessibility, firewalls, and administration. Can expert systems be developed that can tag information with credibility level, identity of source, cultural nuances, etc., automatically as it is inserted into the KB? This will likely require a synergistic combination of soft and wet ware.
- The question was raised on whether this was a KB or a database. The answer was KB as it will contain more than just information that can be encoded into a database.
- Commanders will have to break the 'control' paradigm of wanting to control everything brought about by the access to real-time information (God's eye view).
- Could use 'wisdom of crowds', 'poll of wise men' in the particular field to develop courses of action but cannot force speed of decision on those not predisposed to make quick decisions. Informed decisions may still not be timely.
- Could track psycho-social profile of best decision-makers or grade the ability to make decisions based on past performance. This could lead to meritocracy rather bureaucracy.
- Immersive training environments to train better decision-makers, e.g., Ender's Game, cultural change will be a factor to allow decision-makers to learn from mistakes. This will likely require a generational change as current leaders age out over time.

- The integration of computers and biology not likely in the time frame as using augmented and mixed reality is better where computer interact with existing biology, e.g., heads-up displays using eyes rather than integrating pictures directly into the brain.
- KB must incorporate the status of laws/regulations, what Nations ascribe to what laws, morals, practices, etc., to ensure force structure/force options decisions are well informed.
- Is the KB a push or pull system? Will it push what information it thinks is required to the appropriate players?
- What kind of encryption/firewall is required to push/pull information down to the unit level?
- Do materials in uniforms, etc., need to add sensory stimulation to speed reaction time and report information back to KB? Man as the sensor? This could allow soldiers to not only improve sensors such as hearing but also feel where what direction a shot came from and send that information back to the KB.

S2 – DRDC Atlantic

TIC 16.3.7 Notes from Study Leader:

- There is a need for knowledge base standards.
- There are underlying issues of ‘trust’ in these systems.
- Need to understand and anticipate the impact of growth of networks of all kinds.

Notes from ACT:

- How do you define knowledge? Encode different languages, how to represent people’s actions within scenarios?
- Possible to use M&S to represent Commander’s intent instead of text as more information can be passed and people will be use to using that medium.
- DRDC Toronto is using M&S for crowd representation.
- Gaming community very useful.
- Inter-agency equivalent of ROE matrix which defines the capabilities, needs and values of all participants.
- Social networking (MySpace)/virtual worlds (Second Life) may be good source/tool for gathering data, related to open/crowd sourcing.
- Civil networks will be important as demography changes and personal relationships/trust becomes more important.
- Game theory may be used to assess credibility.
- Uncertainty levels must be incorporated and assessed (expert systems / AI).
- Tracking providence of the information through the system.
- Methods for knowledge solicitation from aboriginal people with oral histories may provide tools for gathering information for KB.
- Need to incorporate cultural traits into the system, anthropology may provide source for taxonomy.
- Do we need to use different sources for information, anthropological studies of tribes?
- Does research need to be focused on how to gather required information rather than maintaining standing KB? Tools and templates of needed information, similar to Rapid Environmental Assessment (REA).

S14 – NIAG Rome #1

Notes from Study Leader:

- Has many levels of complication: governmental, policy, regulatory blocks – volume of data and info:
  - Data level – Not bad, benefit from faster and faster processor
  - Info Level – Limited by current algorithms, not many advances in past 20 years
  - Knowledge Level – Poor at modelling the human, at multi-level interaction, at transduction, at complexity.
- DCGC – Distributed common ground system is possibly a step along this path.

TIC 3.1.6 – Report from Mr. Ennio Giaccari, ITA

Facilitator: Salvatore Rampino

What is your understanding of the capability?

The operational environment, envisioned in the 2030 time frame for the expanding coalition and its expeditionary missions and forces, will be characterized by increasing complexity and dynamicity and by the consequent necessity to increase the automation support provided to human decision-makers to collect, handle, exploit and share non-homogeneous and non-certain information. Identification of adversary's strengths, vulnerabilities and potential behaviour is at present largely performed by expert humans with a consolidated but inherently limited capability to correlate information and to handle uncertainty. While information collection and tools will allow in the future the compilation of a wider base of knowledge, tending to but never achieving the holistic, all encompassing, "perfect" knowledge, the capability at stake is to be able to exploit such knowledge and to reduce significantly the level of uncertainty in the context of a dispersed, netted community of stakeholders.

How would you describe a possible solution or solution approach for the capability in the context of the Issue in the 2030 time frame?

The suggested approach is to develop a number of enabling technologies in the framework of an organisational and functional architecture that accounts for the roles and interactions to be assigned to humans, supported by properly augmented computerized, decision support systems and, in perspective, to autonomous computerized systems, such as robots. An efficient and effective planning life cycle, from information collection to exploitation, can only be achieved balancing automation with human prerogatives. A holistic knowledge base, as such, is not an objective in itself, if not specifically designed for the purpose and integrated in a system concept ultimately generating the desired capability.

The solution perceived by the group includes therefore standardization of intelligence data bases and harmonized integration of further data collection sources, as well as developing knowledge representation and handling methodologies integrated in cooperative, self-learning decision systems, using prediction and optimization techniques, but based essentially on a knowledge shareable with humans.

Rating of pertinent technologies is provided in the following table.

Table H-1: Table of Technologies Related to Managing and Exploiting Very Large Data Bases.

Critical Capability	Envisaged Solution	Technology Area	Constituent Technology			
			Promising but immature	Under development	Leverage commercial development	Mature in industry
Decide and plan in complex operational environments where massive and uncertain (e.g. imprecise, contradictory..) information may be available	Cooperative self-learning decision systems using prediction and optimization techniques, based on knowledge shareable with humans	A09.06 : Optimisation & Decision Support Technology B10.12: Optimisation, Planning & Decision Support systems	Autonomous learning Evolutionary algorithms Swarm intelligence	Robotics Human-Robot Interaction Symbolic information processing (able to handle more uncertainty) Domain ontology	Simulation Bayesian Inference Markov Decision Process	Classical optimization methods Statistical methods

Is there a roadmap to your solution?

Considering the present fragmentation of efforts on technological matters associated to this domain and, above all, considering the unbalance between the high level investments needed to progress significantly and the relatively small market opportunities for industry, NATO should recognise the challenge as such and aggregate the presently dispersed efforts into a dedicated research programme.

This would not only fix the objectives for technology improvements in a coherent framework but would also:

- Monitor developments in the civilian/commercial/scientific world.
- Train and educate people.
- Define methods/metrics for evaluations of future planning systems.
- Model the operational environment, the actors, the actions and the knowledge for simulation of the environment evolution.
- Development experimental solutions, testing all promising technologies, even addressing limited sub-domains.

How would you assess the likelihood of a gap in the 2030 time frame?

Currently there is a big gap in terms of strategic and operational planning due to non-homogeneous, fuzzy and not properly shared information. This will be probably mitigated by 2030 thanks to a number of technological developments already ongoing to pursue various net-centric programmes and to implement better tools, but the group estimation is that the “uncertainty” gap will not be sufficiently mitigated unless a specific programme is launched.

This programme should address all cultural, organisational, procedural and technical issues related to cooperative build up and sharing of a fully fledged, knowledge-based, decision support system, properly handling the uncertainty features of information.

How would you assess the impact of the capability gap on NATO operations in the 2030 time frame?

As stated above, the complexity of the operational environment, coupled with the acceleration of changes, the time compression of the planning process and the employment of high technology systems at all levels will jeopardize NATO operations effectiveness if the subject capability will not be pursued and adequately improved. In particular, this capability gap will make it difficult to quickly adapt to new missions/ operations or to face new forms of antagonism, shifting an excessive load on human operators and decision-makers and exposing them to an unprecedented level not only of labour, time and mental effort, as needed for the analysis and data elaboration of massive quantities of heterogeneous information, but also of psychological stress, caused by the awareness of the uncertainties in the context of the decisions to be made.

Are you aware of institutions which are tackling this Issue?

Research is currently performed within the NATO community by Research Centres (non-defence and defence), Industries and Governmental Agencies, addressing relevant technologies, most being still at low TRL levels (2 – 4).

However no programmes are known to exist that could lead to the implementation of the whole integrated set of tools and systems capable to fill up this gap.

S17 – Kingston

TIC 8.3.1 Notes from Study Leader:

- Move from an e-mail paradigm to a blog and twitter paradigm, to a continually connected and greatly enabled and informed tactical picture.
- Wet wear connectivity and situational awareness.

S18 – DRDC Ottawa

TIC 16.3.7 Notes from Study Leader:

- Is the WWW a shared holistic knowledge base of sorts?
- Data search, data mining, data extraction: Look for image-based query of a database – and audio and signal processing-based query.
- How do you do biometric identification – who is driving the bus that is crashing the road block?

S22 – DRDC Suffield

TIC 3.1.6 Notes from Study Leader:

- Moving from deterministic to stochastic models and analysis but changing the understanding and acceptance of the decision-maker is slow and difficult.
- Can social networking be used as an agent provocateur?
- ROEs: Boolean rules work in robotics but fuzzy rules don't – issues of pervasiveness, i.e., robots will pursue ROEs relentlessly.

TIC 7.3.2 Notes from Study Leader:

- Robotic resupply.
- Force magnification or multiplier – crew augmentation in a virtual sense.
- Gladiator – second generation ground vehicle from Carnegie Mellon University, remote tank crew or embedded AI – reliant upon high fidelity, high speed and reliable communication links.

- Who studies the human challenges of adapting to a one soldier to many machine interface on the battlefield?

S24 – DRDC Toronto

TIC 16.1.5 Notes from Study Leader:

- How could you or would you change the NATO construct and what would you change?
- NATO is a puppet with 26 puppeteers.

TIC 16.3.7 Notes from Study Leader:

- Who challenges the knowledge base?
- Group think – accept info that validates the group's goals – and isolates info that is counter to the group's goals.
- Does a personality profile provide insight into behaviour decision-making?

Technology Focus Areas

- Tools to validate data entry, i.e., stress level indications of voice prints, multi-source consistency checking, multi-level fact checking.
- Semi-autonomous web or media content monitoring and analysis.
- Agreed to framework for initiating and building a focused knowledge base of high fidelity adapted for the operation, location and circumstances at hand.
- Agreed to knowledge base standards.
- Persistent webs of sensors and communications.
- Immersive training environments, games for decision-makers.
- M&S support to the development, communication of, and ongoing analysis of a plan or situation for the decision-maker.
- How does one system 'trust' another, security and accuracy of information?
- Matrix view and analysis of all participants' capabilities, needs, and values.
- Biometric identification at short, medium or long range.
- Fuzzy logic for autonomous systems.
- One too many – What are the rules and interfaces for the future one man controlling many machines?
- Study the relation between personality profiles and the behaviour and decision of a decision-maker.
- Autonomous learning.
- Evolutionary algorithms.
- Swarm intelligence.
- Human-robot interaction.

Solutions

- The solution includes standardization of intelligence data bases and harmonized integration of further data collection sources, as well as developing knowledge representation and handling methodologies integrated in cooperative, self-learning decision systems, using prediction and optimization techniques, but based essentially on a knowledge shareable with humans.

H.5.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Any knowledge-base solution must consider feedback and avoid being unidirectional. Therefore, feedback loops need to be included in any solution. This required to keep the db refreshed and updated as well.
- There is a need to consider means to validate information and the knowledge base. The history of the information, source, confidence level, time, geographic position, etc., need to be tagged to the data so that it can be tracked through time.
- Any knowledge-base solution needs to include HUMINT, which helps determine intent. Hence, any future knowledge-base cannot be solely a technology-based solution. Technology aides to assist HUMINT could also be considered. 'Tech Support' or a reach back capability could support units by providing the relevant information from a constantly updated database on a push or pull basis. Data mining would be required between information acquisition and a distilled, finished intelligence product. Cautionary note that there can be cultural differences from one area to another, making it important to have different algorithms available for the data mining dependent upon where you are operating. The encoding of cultural information will be of particular note as we move from kinetic warfare to the battle of the narrative. Cultural data will be important and must be available down to the tactical level.
- A toolset is required to facilitate intelligent pull of information from the database. Artificial intelligence can provide alerts to the availability of relevant information to initiated searches.
- There is a need to retain and analysis the history of the information. Associated with this, algorithms can be developed based on observed trends within the database to provide predictions.
- A spectrum of decision-making tools is needed to span from the analytical to the intuitive.
- Need to incorporate tools that will look at multimedia, not just textual content.
- Lack of cultural understanding in the input system needs to be addressed. Also, will cultural differences be diminished in the future or will culture be increasingly fragmented as smaller identity groups are made possible, as the result of on-line processes/proprietary systems? Another cultural aspect that could be included is gesture analysis – how something is said can contribute to assessments of the quality of the information. Culture should be a consideration during the planning phase of an operation. In addressing cultural factors, perhaps some cultural translation device would be useful. Culturally, need to consider environment – what might be acceptable in one environment may not be accepted in another. Need to consider cultural barriers in the future. Perhaps increased information will lead to further cultural fragmentation.
- Human limitations will also be a consideration – too much information will affect ability to analyze. Filters needed to prioritize information, so that only important information is highlighted. Semantic information analysis will be a future area of work. There is also a requirement to decrease the workload required in the uploading of intelligence database by small units. For instance, a means of changing verbal input into text would facilitate the maintenance and augmentation of a database.
- How do you assess whether the system is working – what is the benefit, what is the intended audience and does information need to be shaped for the different audiences?
- How is information parsed for different audiences? Not everyone needs to know everything. While information pull will be routine, there are some things that need to be pushed quickly (i.e., there is an incoming missile). While humans will continue to be important, some sort of artificial intelligence will doubtlessly be necessary. History of the information should be kept, as it provides a means of verification and enables assessments. Minkowski – has done work on a predictive tool that looks at where information has come from and looks to predict future trends/

decisions, etc. Semantic search tool would be useful as well. Need to reduce the enormous amount of information that will be gathered by future sensors to reduce the analysis problem. Highlights the relevant areas where human analysis is required.

- Mechanisms/tools to filter information are required so as not to overload/distract operators.
- Artificial intelligence and pattern recognition are important, but how do we leverage these so that we get further in the future? Computers may be built around different architectures in the future, to more closely emulate human thought. Imagery will replace text as the primary means for gathering, sorting and displaying information.
- There are branches of science that embrace human systems / human factors (i.e., anthropologists) – so need to find, for example, anthropological models that will help with future predictions. The requirement to gather and encode cultural data will become increasingly important as the Alliance moves from kinetic to ‘battle of the narrative’.
- Public choice needs to be considered to optimize how parliaments, etc., make decisions. Plus, Public choice literature will provide a rich source of information.
- Will it be possible to quickly translate verbal information into digital information? Some kind of automated tool would help with efficiency and also need to have a filter for relevancy.
- Need to catalogue information in a way that makes it accessible. There are questions whether sorting will be needed in the future. In the future, there may be a need to categorise less rather than more, which implies collecting a vast amount of information and then using some sort of search.
- Intelligence augmented by geo-tagged photos with GPS coordinates so that the information is linked to a location. This information can then be pushed to a patrol entering an area via PDA-like devices. If new or revised information is received by a patrol about a person or a location, it can be recorded and channelled to others operating with that person / in that location.
- Image search and correlation will be a critical enabling capability for database. The ability to associate images taken from several different sensors at different times will be important. These images could be used to develop stereoscopic/holographic images. We need to close the gap in time required to conduct planning and image searches and recognition. Obtaining and managing a large amount of images would be an intensive activity, so some kind of means of reducing the workload via automated tools would be required.
- Information resident in the database can be used to build models for ‘what if’ analysis in advance of operations. Associated with this, a more holistic database would be required, which contains the bulk of information and allows users to drill in for specific information required. Tools to manage and compile this information would also be useful. Artificial intelligence would be needed to enhance the utility and flexibility of these tools and present the information in format that is useful to the user. The tool should also suggest format to the user on how the information could best be displayed.
- Biometrics is a field that could produce useful intelligence, but a real-time capability would be required. This requirement for the real-time analysis of information extends across the full spectrum of capabilities.
- Opponent modelling along with adversarial thinking can be used to test courses of action and to do options analysis.
- Recursive agent-base modelling shows some value for opportunities for advancements in database building and maintenance.
- Heuristics / artificial intelligence needs to be developed to automate the analysis of the vast amounts of data collected from sensors so that only relevant data is provided to humans for analysis.

- Is it necessary to make a distinction between information and knowledge? How do you structure information so that knowledge is derived? Possible solutions include geo-tagging, metadata tagging, etc. Database needs to allow manipulation so that information can be derived to achieve different knowledge elements. Data has to be interoperable and also taking into account its use by allies, which implies a requirement for multi-level security.

Technology Focus Areas

- Encoding confidence levels and other providence information with the data incorporated into database.
- Data mining.
- Agent-based modelling.
- Reach back capability.
- Encoding cultural data.
- Multi-level security.
- Firewalls.
- Artificial intelligence.
- Search techniques.
- Metadata labelling and management.
- Metadata management.
- IT tool development.
- Knowledge management.
- Tool development.
- Semantic search engine.
- Language translation.
- Video capture, video recognition and analysis.
- Predictive tools.
- Filtering tools.
- Computational science.
- Image search, recognition, analysis.
- Encoding cultural information.
- Presenting cultural cues to Commanders in the field in real time.
- Accessing social sciences.
- Translation of text, audio and video.
- Metadata management and labelling.
- Search tools.
- Metadata management and labelling.
- Real-time data push.

- Image search and analysis.
- Image tools.
- Decisions tools.
- Biometrics.
- Modelling tools.
- Metadata management and labelling.
- Multi-level security.

Solutions

- None identified.

H.6 CAPABLE OF MEASURING, ANALYSING, PREDICTING AND ANTICIPATING RISK WITHIN A COMPLEX ENVIRONMENT

H.6.1 Theme-Issue-Capability Description

NOTE: Of the forty A-List Theme-Issue-Capabilities (TICs), there were a total of 11 TICs that were the same capability and they have been combined in this section.

TIC 3.2.5 – Planning Under Deep Uncertainty

In the past, where conditions were relatively certain, Alliance defence and operational planning processes were deliberate and reflected 'strategy as design'. The fluidity and pace of change within the emerging globalised environment will increasingly demand that planning for Alliance operations will be done under conditions of deep uncertainty. Deep uncertainty is present when decision-makers do not know or cannot agree on the current system model of how things fit together, prior probabilities, timing and cost. This will require a new suite of methods and analytical tools to support decision-makers in a 'strategy as process' manner to develop capabilities that are flexible, adaptable and robust.

Issue – Financial Planning in Government

Current financial planning processes and the public accountability within Western governments do not support dynamic/responsive military planning for capability procurement. Need for better ways of cash managing defence budgets? Might include strategies to deal with price fluctuations of required assets, such as commodities, e.g., through hedging strategies.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 3.4.4 – Planning Under Deep Uncertainty

In the past, where conditions were relatively certain, Alliance defence and operational planning processes were deliberate and reflected 'strategy as design'. The fluidity and pace of change within the emerging globalised environment will increasingly demand that planning for Alliance operations will be done under conditions of deep uncertainty. Deep uncertainty is present when decision-makers do not know or cannot agree on the current system model of how things fit together, prior probabilities, timing and cost. This will require a new suite of methods and analytical tools to support decision-makers in a 'strategy as process' manner to develop capabilities that are flexible, adaptable and robust.

Issue – Future Structures

The need for agile, flexible and adaptive answers to (intrinsically unpredictable) changes in the security environment warrants a radical rethink of how Armed Forces are structured and maintained. Models from the business world may be examined for applicability. Outsourcing of services and rely on market adaptation mechanisms must be considered

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 4.1.6 – Different Paradigms in Decision-Making

The interconnected strategic environment of the 21st century has given rise to increased uncertainty and complexity. These emerging threads have been grasped by increasingly adaptive opponents. For the Alliance to be successful in the coming decades, it will have to undertake politically and militarily complex missions requiring a comprehensive approach. The interaction of changing circumstances in the strategic and operational environments will require different paradigms for decision-making. The complexity of future Alliance operations implies both quantitative and qualitative changes in the information and analytical support needed to make good and timely decisions. This could mean a move from the current paradigm of 'command and control' to one of 'focus and convergence'.

Issue – Achieving Common Objectives

The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities reside in each of the organizations on achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 6.2.6 – Staying Power

It seems probable in the coming decades that Alliance military forces will be engaged on a more or less continuous basis in operations requiring significant numbers of the troops and weapons systems. To successful undertake such operations over time will require 'staying power' from Alliance Nations to remain engaged. There is a perception that Alliance forces currently do not possess sufficient staying power to engage a tenacious, adaptive enemy that seeks to keep Alliance forces engaged for a long period. Staying power must be developed at several conceptual levels:

- Political – political priorities and messages must be aligned to keep forces engaged.
- Operational – clever campaign design, use of technology, avoidance of too ambitious operations and increased forces.
- Tactical – operations are typically undertaken by small units demanding improved equipment, protection and tactics.

Issue – Facilitate Political Stamina

Cost and risk sharing, retain the ability to react to emerging security challenges while holding true to long-term commitments in reconstruction endeavours.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 6.3.7 – Staying Power

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- Operational – clever campaign design, use of technology, avoidance of too ambitious operations and increased forces.
- Tactical – operations are typically undertaken by small units demanding improved equipment, protection and tactics.

Issue – Establish a Workable Division of Labour / Collaboration Structure with Other Agencies

Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours.

It should be noted that the 'civil-military loop' implied here goes beyond what is currently understood under the term 'CIMIC' (civil-military cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civil-military interaction here is aimed at achieving a higher order objective and is not 'owned' by the military.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 8.1.6 – Strategic Compression

Strategic compression can be defined as the forming of unexpected casual relationships and breaking of expected causal relationships among the tactical, operational and strategic levels of conflict in the political, information, military and economic domains. This is a combination of the 'strategic Corporal' and the 'tactical politician'. This is brought about by the interconnectedness of the globalised environment and the pervasiveness of the 24-hour media cycle supported by almost instantaneous information systems and networks allowing more people access to more information. The coalition nature of most future operations will increase the importance of controlling strategic compression to maintain the coherence/viability of the coalition.

Issue – Different Causal Relationships Across the Levels of Conflict / Organisations / Endeavours

Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How do accountability and media coverage / pressure affect the Issue?

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 9.1.3 – Dual-Use Technology

The concept of dual-use technology has most recently been used to describe the use of commercial technology for military purposes. With the bulk of research and development funds being expended on commercial development of technology, it very likely such developments will produce systems that will have a collateral military use. As scientific advances increase exponentially over the coming decades, there will be a requirement to monitor commercial technology for those developments that could give possible adversaries a mechanism to produce weapons systems.

Issue – Spin-In of High Quality, High Pace Innovation

Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services. One issue is how to guarantee security of information and security of supply. Another is how to maintain technological dominance. One element is to keep track of how advancement in civil domains can be spin-in effectively in the military domain. Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications. This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 10.2.2 – Non-Military/Non-Violent Threats

The Alliance will face a variety of hybrid threats in the future. These include non-military threats where the source of the threat are non-conventional military forces and non-violent threats wherein, though it may be an enabler or an intended consequence of the action, violence is not an inherent element. These threats could come about through deliberate action, accidental occurrences or natural disasters. The cause and effect of these events is not limited by borders and are characterized by difficulty in prediction, detecting, localizing and typically involve little or no warning. They require trans-national coordination and inter-agency cooperation to resolve. Examples of these types of threats include:

- Computer network attack;
- Pandemics;
- Mass migration; and
- Natural disasters.

Issue – Risk Prioritisation, Balance of Investments and Scaling Problem

Ability to order all hazards risks across probability and impact. Combining a long-term perspective upon military core responsibilities and competences, while simultaneously answering to emergent risks, threats and potential catastrophic events (= small scale causes with large first and second order impact consequences). The latter may overwhelm current capabilities – how to deal with that?

For non-traditional threats there will be a (initial?) lack of threat predictability. There’s a need to create new early warning mechanisms for cyber attacks, tsunami, pandemics, etc.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 12.3.2 – Three Domains of War: Physical, Mental and Moral

Kinetic activity associated with traditional military operations has been joined by actions in the moral and mental (information) domains as equal components of a success campaign plan. The war of ideas, hearts and minds, fourth generation, amongst the people has stressed the relevance of the moral and mental domains. As asymmetric adversaries avoid exposing themselves to the superior conventional force of the Alliance, the importance of actions outside the physical domain become more obvious. Within irregular warfare the importance of the moral domain becomes dominant as the security of the people becomes an overarching goal. In the future, physical actions will be used to enable the achievement of objectives in the mental and moral domains.

Issue – Balance of Investments in the Three Domains

Despite the growing focus on campaigns to win the 'hearts and minds' and an effects-based approach to operations, there will always be a requirement to maintain dominance in the physical domain. How to balance of investment between investments in capabilities that act in the physical, the information and the moral domain?
Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 13.1.2 – Coalition Operations

In the future, no single instrument of power will be able to solve complex crises. Coalitions will be used extensively to conduct all manner of military operations. Members of the coalition will provide various capabilities to the force while accepting differing levels of risk. Coalition operations will highlight areas such as interoperability and common doctrine. The ability to develop a common strategy within a common legal framework will be crucial to the achievement of coalition objectives. This Theme raises issue of interoperability, role specialization, training and sharing of technology.

Issue – Burden Sharing

Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

TIC 16.2.2 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the 'whole-of-government' or 'comprehensive' approach; and
- The need to garner public support for ongoing operations.

Issue – Burden Sharing

Ways to distribute risks and costs in a fair way – not in the least to ensure coalition solidarity and lasting (national) political and societal support.

Capable of measuring, analysing, predicting and anticipating risk within a complex environment.

H.6.2 JO 2030 Phase IV Out Reach Results

S2 – DRDC Atlantic

Notes from ACT:

- Business communities to assessment of risk all the time, use tools/methodologies for banking and insurance industries.

S3 – Centre Foreign Policy Studies, Dalhousie University

From CAN Rep Notes – Sandy Babcock:

- Information sharing (or lack thereof) is the most significant hurdle to analysis, recognition of the problem and decision-making.
- Trust, credibility, transparency and regulatory alignment are 'all important'.
- Any efforts dedicated to development of multi-level security systems will be beneficial.
- Networks/relationships have to be build before operations.
- Analysis of business interests and their impact on operations is not well researched (Shell and Nigeria).
- Journalist and multi-national corporations have their own intelligence/information networks that are established in areas of operations well before NATO takes interest.
- Foreign intelligence agency or ability to build own intelligence picture is important for good decision-making that is not dependent on other people's information.
- Discussion forums at a technical level are critical to formulating decisions at political level.
- Can you address the moral/mental domains by only acting in the physical domain?
- Most current operations are 'generational issues', they can only be changed as the next generation of inhabitants takes political control of the Nation.
- Requirement to move from 'need to know' to 'need to share'.
- Scenario development within the defence planning process is held hostage by political input.
- Investments in indigenous education can pay great dividends.

S11 – Brussels

TIC 10.2.2 Notes from LtCol. Christian Micha:

How would you describe a possible solution or solution approach for the capability in the context of the Issue in the 2030 time frame?

- Better cooperation (people – systems).

- Standardisation of all military and non-military capabilities (determining interfaces for interoperability between NATO, EU, UN, Nations and NGOs, etc.).
- Inter-agency exercises.
- Faster decision-making and action possibly based on standing structures for disaster relief (a kind of Disaster Response Force (DRF) besides the NRF).
- More interaction with NGOs.
- Better relationship (coordination) with other (international) organisations active in this area.

Is there a roadmap to your solution?

- Simulation tools for choice – coordination – engagement of capabilities.
- Optimization tools for allocation of specific assets.
- Issue – Is there enough time available to use these tools to support decision-making in case of (natural) disasters? The challenge is to create sufficient situational awareness in a very short time. So tools to create this situational awareness (by clarifying 1st, 2nd and 3rd order consequences) by using various types of sensors will create a lot of added value.
- Avoid duplication of (expensive) capabilities by (inter)national coordination and cooperation.
- What about ‘outsourcing’? Can we consider the ‘outsourcing’ trend as a positive one in this area? In this area (emergency relief and consequence management) it is crucial to have absolute certainty that the resources will be available when necessary and within the planned time frame. In case of outsourcing there must be very clear (contractual) guarantees regarding the availability of the resources. So the Panel suggests to avoid outsourcing of the really crucial functions for emergency relief and to make sure there is a minimum of ‘in house’ capabilities.

Are you aware of institutions/people already working on solutions to this capability requirement?

- A lot of research is being done in the area of ‘complex adaptive systems’. This ongoing research has to be oriented towards this specific field. The socio-technical systems we are focusing on are also complex and adaptive systems. The challenge is to find ways and means to make these complex socio technical systems as stable and robust as possible.
- Research of ‘system-of-systems engineering’ will create a lot of added value for the type of capabilities we are looking into. The Panel shared the opinion that in the area of consequence management a strongly centralized approach should be avoided. We have to strive towards a decentralized sense- and respond approach. The closer a response capability is situated to the reality of the field the more accurate the situational awareness and the quicker / more tailored the reaction will be.

Conclusion – A lot of progress can be made by transposing/tailoring available knowledge and tools from other areas of expertise towards this capability area. It is probably not necessary to invest in fundamental research as nothing really ‘new’ has to be invented.

S13 – DRDC Office of the Chief Scientist Session 1

TIC 9.1.3 Notes from Study Leader:

- S&T advantage – how do we protect the advantage? A – guard it but it always leaks, or B – accelerate the pace, US is 1 generation ahead of allies and 2 generations ahead of foes -> how does this change in 2030 as more and more comes from the global world?
- Dual use – is this a consequence is less and less control by state institutions.

- Politics and policies can be in bedded in the tech.
- Opportunities for dual-use technologies may be countered by greed and position in the market place and measures to protect same.
- Need to influence how information gets in and used.
- Societal paradigm shift – society moves to accept as a necessity the need to be IN and actively in the security world.
- Health – many sides: – exponential growth in need – targeted genetic insertions – medical tourism – challenges and changes associated with shifting societal demographics and longevity.
- Ubiquitous communications.
- What are the moral and ethical limitations?
- Ownership of the producer of the info internally = knowledge retention.
- Human cloning or human disease vectors.
- Co-opting nature for good and bad.
- Monitor dual-use technology by commonalities of interest – active internal community watch.
- Open source ‘things’ are not controllable.
- Lower the bureaucratic overload of research efforts – make more use of SKUNK works.

S17 – Kingston

TIC 12.3.2 Notes from Study Leader:

- Mental is both rational and emotional.
- Slide consistency with regards to mental and information.
- Complex environment by definition negates the ability to calculate risk.
- The glass half full says that greater human connections and networking will move Nations further down this road C3 vs. C2 – Mil needs the C2 in the course of its range of response but needs engage in C3 in the middle and to the left of open conflict.
- Non-mil orgs need to have more people resources to enable their important roles in the understanding and managing risk in the complex – currently, in an op, this falls largely to the military initially because they see the problem and they have the numbers.
- Duty with discernment.
- Trust is key to the day-to-day working of a unit and an operation.

TIC 12.3.2 Notes from Dr. Gitanjali Adlakha-Hutcheon:

- TIC – In the issue change mental to information for consistency.
- Complex environment by definition negates the ability to calculate risk.
- By 2030, we’ll be better at joint, inter-agency-ops enabled by technology for information sharing (already happening social networking).
- Comprehensive approach – breaking down institutional norms or stereo = typical thinking and relationship building through networking.
- As we insert more components into the stew that we call the response the intent will match the results more than it has historically.

- Learn to operate within complexity rather than reduce it; nowadays are talking to people whom we never would have in the past.
- Using other tools in the tool-box such as education on the cognitive plain; talk to younger personnel returning from theatre like Captains returning from Afghanistan.
- Going from the spectrum of command and control to collaboration and collegiality.
- (On-line games – the need to collaborate to succeed is built into the base of the game).
- Other Government Departments (OGD) do not understand CC, not in their culture while the Generals believe it is their way or the highway.
- References:
  - Duty with discernment – LtCol. Rick Walker ethics.
  - Human Enhancement Ethics Conference, Western Michigan University – 28 and 29 March 2009 and the link to the related internet site: http://www.humanenhance.com/index.html.
  - Here is the link to their US MHAT V report: http://www.armymedicine.army.mil/reports/mhat/mhat_v/mhat-v.cfm.

S18 – DRDC Ottawa

TIC 9.1.3 Notes from Study Leader:

- Need to develop expertise retention strategies.
- Dual-use technologies – many perspectives, soldiers in Afghanistan with PDAs, notwithstanding the rules and regulations prohibiting them.
- Don't discount the possibility of technology surprise against the West.
- Nuclear weapons vs. nuclear power?
- Cognitive radar – context of meta level inference or tracking- pattern fitting and anomaly analysis – tracking changes.
- Increased intelligent instrumentation – better display, representation and layering of info.
- Human operators still don't trust the trackers – trust builds when the system works.
- Today it is possible to collect a great deal of data/info and it is possible to shape that info to match a variety of conclusions.
- Human in the loop -> who goes to jail? Who is responsible?
- GUI to NUI – graphical to natural user interface.
- Current detection algorithms are 40 years old, but this still is an area of great potential, i.e., ATR automatic target recognition and GMTI ground motion target indication.

S20 – Canadian Forces Directorate of Future Security Analysis

TIC 3.4.4 Notes from Study Leader:

- Need to be adaptive, flexible and integrated.
- Need to be structured and cultured to work in a complex adaptive system.
- Able to take advantage of JIT capability acquisition often from a private contractor.
- Measure and match our own capability vs. the threat-based technology.

- Military is like a fire department: need to really worry about what we don't know will happen – be proactive vs. reactive.
- Negative and positive reinforcements of good will and trust.
- HARM oil eating bacteria? – Potential HARMs.
- Learn more about managing the conflict at the margins.
- Limitations – when to hold ground and when to leave – an effort to study and know one's limits.
- Interoperable.
- Interests – aligning and defining interests.
- NATO could be better at resource sharing and niche exploitation.
- Political-economic-financial-technology-infrastructure partnership risk.
- 2008 – All source intelligence cells and info sharing – the integration and management is done in a central C4ISR management cell.
- RISK today is at the coal face – in the future RISK will be managed and removed from the front.
- Where to manage and decide upon the RISK and how to build the structure and organisation that supports and enables these decisions.
- RISK ends up as a quantifiable measure and that usually is a $.
- Who do you believe – 1,000 economists or the 2 who predicted the 2008 fall but where not heard?
- We all will believe what we want to believe.
- Amorphous information.
- Organizational change vs. organizational inertia.
- Noise and data and information – filter and connect the dots.
- Naval Officer of the Watch is a central point of info and has to prioritize and decide.
- What is cognition and what are its limits?

TIC 3.4.4 Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Cannot monitor technology let alone dominate it.
- Planning structures are very defence-centric, capital programs take ten years to get off the ground, with COT develop services that make it easy to go to the industry. Such ability will in turn will enable the militaries to not require having to guess what will be needed in years to come.
- Example UAVs – easiest way is via leasing and so can have a very responsive system. Will be able to employ just-in-time acquisition and leasing capabilities.
- Defence will be delivered beyond DND, forces to develop the ability to tap commercial capabilities.
- The Issue speaks to the solution for developing this capability – solution is outsourcing – reliance on market adaptive mechanisms; comes down to the dollar sign.
- Will require a comprehensive way to detect potential threats.
- Willingness to recognize our own limitations, are being geared to being flexible, adaptive, agile, etc., and therefore are unable to respond to any one thing.
- Will need to get better at interoperability, resource sharing; NATO – an opportunity for resource sharing that will have to be better employed.

- Not look at specialization as a bad word. Country X develop A and country Y develop B and so on and so forth.
- Today integration of risk management function is done in a centralized fashion. Perhaps in the future, risk analysts should not be at the 'front'; do this remotely away from fire power.
- One solution is to be networked.
- Comprehensive scanning will be needed.
- Ability to recognize that 'X' needs attention (i.e., ability to respond to emerging threats) hierarchy in the way of flagging risks.
- Analyze risk based on what's relevant at a specific time.

TIC 9.3.1 Notes from Study Leader:

- Exercise in autonomy – how do you know what you know?
- Whatever constraint we may have in using a technology, others may not or do not have those same constraints.
- Issue is control – can or cannot control technology.
- Most technology advance today is being delivered by industry.
- What areas should the military continue to lead in and to hold on to?
- Why do people adapt a technology – to circumvent an obstacle?
- Guarding technology is far harder today than in the past.
- IP and trade secrets and multi-national interests are all obstacles – everyone is in the game.
- Commercialization – the money today isn't in the military industrial complex.
- Watch what's changing: structural, globalization, information, knowledge – we are at risk of losing our ability to shape military technology.
- This TIC is written as if we are already and will remain out in front?
- Total systems approach – need a comprehensive model of how these 'things work and interrelate.
- Need to anticipate the 'naughty' people – meta and trans-national adversaries.
- We are behind the threat: the adversarial mind – the commercial mind.
- Economic and social systems – the power of the dollar.
- Need to be plugged into long-range business models.
- Loyalty – changing from firm or permanent to iffy and shifty.
- Bureaucratic inertia and lethargy.
- We assume dominance at the same time that the 'West' is in decline.
- Commercial vs. military – how criminal networks exploit – interests – strategic criminal objectives.
- If the focus is on technology we will always be playing catch-up – can't dominate and control technology.
- Need to track and anticipate commercial developments – then play what if and what can we do about it.
- Underlying issue is what are the goals and objectives of the 'player'.

TIC 9.3.1 Notes from Dr. Gitanjali Adlakha-Hutcheon:

- The Issue within this TIC is the extent to which one can control technologies within complex environments.
- Dual-use technology developed as much by the military as by its adversary. Because of intellectual property, power within capitalistic society, militaries, Government of Canada will potentially not know what the adversaries are developing.
- One of the issues associated with dual-use technologies is that these are written-up / thought as military and civil not necessarily as the reverse. Dual-use technologies will be a luxury by 2020. For instance, at present militaries are getting out of technologies such as space, remote sensing, i.e., technologies that were so capital intensive that they were generally developed for militaries by militaries or jointly along with defence industries.
- This becomes relevant when viewed through the historic context when most technologies were developed by industries for the military. Today a number of technologies are still developed by industries but not for military-purpose alone.
- Hence, militaries will lose their ability to steer development of technology(ies). We (militaries) will be chasing technology development. Need to get into the mind of the adversary and beyond into the minds of the business folk, i.e., be plugged into people's long-range business model. Will need to be able to anticipate economic theory – dollar equates power and influence. Will need to open oneself up to the market and what it offers.
- Will need to partner with people that one does not traditionally partner with.
- To maintain the edge will look into a systems approach and not a technology- oriented approach. If the militaries remain focused on technology then they will remain in catch-up mode.
- Will require an anticipatory mode with a comprehensive approach of how the various elements interact with one another.
- In 2030, loyalties will be split and will be defined differently. They will no longer be forever, so a person may be loyal to X for a certain aspect and to organization Y to another.

S21 – DRDC CORA Strategic Analysts

TIC 12.3.2 Notes from Study Leader:

- The use of the term 'moral' implies that this is normative – when this is really a political issue.
- How 'existential' or near and present is the threat? If very near then all options are available – if not then one manages the margins or the edges.
- Moral is a problematic term – should be cognitive or psychological domains.
- Wording of the TIC already incorporates a certain perspective.

S22 – DRDC Suffield

TIC 4.1.6 Notes from Study Leader:

- Options analysis and risk mitigation.
- Risk of modelling chemical exposure good / but lack good biological risk assessment tools.
- Chemical biological risk is so low that it begs the question does it merit great stress and expense associated with designing, acquiring, and deploying individual defence systems.

TIC 10.2.2 Notes from Study Leader:

- This is a well-researched area already.

S24 – DRDC Toronto

TIC 4.1.6 Notes from Study Leader:

- Tolerance – risk – uncertainty.
- Tolerance of conflict and different opinions.
- How does team decision-making work and information sharing in teams work?

TIC 12.3.2 Notes from Study Leader:

- This is a risk to whom? The Alliance – the State – the operation?
- The psychology literature on decision-making in uncertainty – assessing, perceiving, and responding to risk individually and as a group.

Technology Focus Areas

- Business risk analysis studies.
- Multi-level information security systems.
- Mixing and matching and exploiting multiple networks, multi-network studies.
- Inter-agency exercises.
- Value of timely and accurate information.
- Tools and procedures to build situational awareness rabidly.
- Promote SKUNK works – feed good ideas but keep them away from larger organisations.
- Embed risk mitigating policies and process into the logic and control functions of the technology.
- Persistent observation and communication.
- Natural user interface.
- How do issues involving high or low trust levels influence risk?
- Data filtering techniques.
- Pattern fitting and anomaly analysis to find early indications of state changes in a situation.
- Algorithm development, an area of great promise but very little advancement over past 40 years.
- Managing conflict at the margins.
- Integrate many risks – political-economic-financial-technology-infrastructure partnership risk.
- Studies of the known, unknown, and unknowable and that reduce the latter two.
- Risk – how pressing is the risk, how existential is it?
- Acceptable risk and return studies.
- Studies of assessing, perceiving, and responding to risk both individually and as a group.
- Policy legal issues in coming clash of persistent social surveillance.
- Context awareness and dual-use pervasive reasoning.

- Use of ambient intelligence and pervasive computing to increase awareness and reduce risk.
- Long-term technology evolution is another factor to be monitorized in order to assess their systemic implications in future scenarios. This will allow prediction and anticipation of risks about the use of these technologies in military or dual-use applications.

H.6.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Some of what we consider risks is often brought about by our own actions or inactions. Better application of root cause analysis may help in the "prevention" stage of risk management.
- Many civil domains have well-developed models for risk management and adaptation (e.g., nuclear power, geology, oil exploration). Benchmarking from them, as well as application to military organizations of principles and techniques already in circulation in the business world, would help.
- Education of decision-makers an essential component of improving RM.
- Ethics may have to be included in assessing (strategic) risks and how – if at all – to deal with it.

Technology Focus Areas

- Symbolic or semantic representation of risks and how humans, teams, and organisations/society perceive and react to them.

  Explanation: At least one team observed that two different individuals can see the same situation and each will characterize it differently with regard to riskiness. Why is this? Evidence from entrepreneurship literature indicates that entrepreneurs are not significantly more risk-tolerant than anyone else, although most people see starting a new business as risky. This seems to be because entrepreneurs just don't perceive what they are doing as risky because they have inside knowledge about local conditions (Harting's example as entrepreneurship researcher). The concept of *measuring* risk in a complex environment requires context on how individuals (and by extension, groups and societies, see below) *perceive* and conceptualize risk.

- Cognitive psychology or social psychology research into group risk perception and behaviour.

  Explanation: Group perception and behaviour is not the sum of its individual members. Some research has been done here, we are confident, but more needs to be known about how individuals interact in teams, both co-located and distributed/networked, to produce different organizational risk tolerances and capacities, particularly in a military environment.

- Development of computational models capable of taking individual risk profile information (and other factors), and simulating team performance against an objective (addresses tactical risk, assists in team formation and COA development).

  Explanation: The possibility was discussed of building a simulation where risk profiles of individual team members were fed into the model, along with information on enemy resistance, terrain, local population friendliness, available infrastructure, or whatever else. Given a set objective, one could analyze how independent variable of interest contributes to mission success. This would allow experiments into what risk characteristics are important for what mission, etc. One could also take that a step further and make a video game out of it.

  NOTE: although agent-based models are in development, this particular application would be research unique to the military, and unlikely to emerge from other sources.

- Models to map risk profiles' and techniques to deal with those in a multi-agent 'comprehensive approach' environment.

  Explanation: How do the various parties in a multi-agent collaborative endeavour – such as a stabilisation and reconstruction mission, where the military provide a security umbrella – come to a coordinated division of labour/work plan that thus justice to the various 'risk profile' of the parties involved? How may, e.g., 'trusted partnerships' ease risk adverseness?

- Investigation of leading indicators to / signals for uncertain events for early warning.

  Explanation: Complex systems theorists are looking at ways to improve the ability to do 'educated guesses' about the future behaviour of intrinsically unpredictable systems (be it climate, earthquakes, ecosystems, or the security environment). Are there large scale variables which can be operationalized and analyzed to predict/gain better insight in political risk, risk of social upheaval, etc., necessitating NATO involvement? For example, it may be possible to collect information on a country's GDP, level of corruption, influence of neighbours, food production, poverty level, religious tolerance, etc., as well as the dynamics over time in those factors, and derive a risk rating which can tell us whether it is likely that there will be a civil war, collapse, etc.

- Meta-modelling of 'security status'.

  Explanation: If you can solve the problem above, this lends itself to a strategic 'security status' model that may be connected to existing models for natural disaster probabilities, bad harvests, disease, water availability and likewise models. Such models would be instrumental to 'give meaning' to otherwise rather technical and isolated analyses of indicators and drivers.

- Development of information presentation models, with trustworthiness of sources built into weightings and priorities; for use by decision-makers.

  Explanation: Decision-makers must deal with many sources of information and often come to a verdict in a short period of time. This TFA involves the development of informational screens, or even suites, which amalgamate various sources, and weight each one based on the reliability and trustworthiness of the information. Sketchy sources carry more risk. Although not explicitly discussed by any of the groups, this implies research into the human factors of data presentation, and the always-troublesome issue of multi-source data fusion. Especially since we might not be talking only about text or numerical data, but possibly raw intelligence sources (SIGINT, MASINT) as well. In more advanced interfaces, other than visual representation may play an important role, e.g., auditive signalling, pressure; but also, e.g., individualised virtual tutors to help with the interpretation of data.

- Societal resilience modelling.

  Explanation: With comprehensive security becoming a more and more complex issue, dealing with security risks must be integrated in a whole of government and, increasingly, a whole of society effort. How can societal awareness, preparation and anticipation, early warning and resilience be promoted and enforced? What role may the military play in terms of education, coordination and frameworking societal resilience?

H.7 CAPABLE TO ASSESS AND IMPLEMENT THE STRUCTURES AND PROCESSES FOR PLANNING / DECISION-MAKING / ACTIVITY COORDINATION / FEEDBACK ACROSS THE VARIOUS ACTORS IN A COMPREHENSIVE APPROACH

H.7.1 Theme-Issue-Capability Description

TIC 4.1.8 – Different Paradigms in Decision-Making

The interconnected strategic environment of the 21st century has given rise to increased uncertainty and complexity. These emerging threads have been grasped by increasingly adaptive opponents. For the Alliance to be successful in the coming decades, it will have to undertake politically and militarily complex missions requiring a comprehensive approach. The interaction of changing circumstances in the strategic and operational environments will require different paradigms for decision-making. The complexity of future Alliance operations implies both quantitative and qualitative changes in the information and analytical support needed to make good and timely decisions. This could mean a move from the current paradigm of 'command and control' to one of 'focus and convergence'.

Issue – Achieving Common Objectives

The increasing number of entities such as military forces, NGOs, IOs and others operating within the theatre during complex endeavours makes the definition of common objectives and focus extremely difficult. There is a requirement to elicit and define the objectives of the numerous players and come to some level of consensus on a way forward that will converge and focus the capabilities reside in each of the organizations on achievement of an overall objective. For the military this implies, e.g., the ability to integrate non-military actions in military planning as part of a comprehensive approach (see also Theme 16 – Political Transformation).

Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach.

H.7.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.7.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Leads to the need for planning and decision support tools that can reflect the (potentially competing/ conflicting) goals of the various actors. Need to mitigate against personal biases and reflect the need for timely decisions. (A good decision too late is no decision.)
- Improved feedback mechanisms required with a minimum requirement for improvements in the speed, accuracy and resource implications of current MOP/assessment tools such as polling.
- Identification of appropriate structures that can best support planning / decision-making / activity coordination across the various actors.

Technology Focus Areas

- Development of advanced comprehensive planning and decision support tools/models (potentially combining both analytic and preferential approaches).
- Potentially aided by research into the discipline of "Critical Thinking".
- Improved performance assessment tools/methodologies (increase speed and accuracy, reduce resource requirements, etc.).
- Research into alternative/efficient "management" constructs and structures (potentially involving organizational theory and concepts such as "focus and convergence" vice traditional C2).

Solutions

- None identified.

H.8 CAPABLE OF ACTING IN DYNAMIC 'VALUE CHAINS' WITH A VARIETY OF POTENTIAL PARTNERS

H.8.1 Theme-Issue-Capability Description

TIC 4.2.13 – Different Paradigms in Decision-Making

The interconnected strategic environment of the 21st century has given rise to increased uncertainty and complexity. These emerging threads have been grasped by increasingly adaptive opponents. For the Alliance to be successful in the coming decades, it will have to undertake politically and militarily complex missions requiring a comprehensive approach. The interaction of changing circumstances in the strategic and operational environments will require different paradigms for decision-making. The complexity of future Alliance operations implies both quantitative and qualitative changes in the information and analytical support needed to make good and timely decisions. This could mean a move from the current paradigm of 'command and control' to one of 'focus and convergence'.

Issue – Information Management

The exponentially increasing amount of potential data, information and knowledge available to decision-makers is resulting in overload and decisions based upon sometimes faulty information. This leads to the necessity to devolve decision-making down to lower levels where the quality of available information is higher rather than retain authority at higher levels based upon the technological capability to do so. In general, in a NEC environment, the traditional 'top-down' stream of information is augmented by a structural 'bottom-up' stream as well as a 'sideways' stream to allies and 'other' agencies involved in the endeavour.

Capable of acting in dynamic 'value chains' with a variety of potential partners.

H.8.2 JO 2030 Phase IV Out Reach Results

S22 – DRDC Suffield

Notes from Study Leader:

- Downward delegation of autonomy.
- Push info down.
- Should devolve info but this pushes up against the compulsion to control.

S24 – DRDC Toronto

Notes from Study Leader:

- Elasticity of command – old paradigm low levels do things but don't know why – new paradigm low levels know what is going on and act but the higher levels don't.

Technology Focus Areas

- Advancing or changing concepts of command and control.

H.8.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- None identified.

Technology Focus Areas

- Organizational behaviour or org theory research into new forms of organization which are agile, maintain clear lines of communication, and have authority to operate across Ministries/ Departments.

  Explanation: To successfully and efficiently operate in novel deployment situations, we need a new organizational logic for whole of Government approaches. Current efforts are much too stove-piped. Just as the 20th century produced the M form organization, the functional structure and the matrix organization, the 21st century requires research into a new logic which will allow new partners to seamlessly integrate under defined conditions and follow one chain of command, and one way of doing business. To be conducted by organizational theories, org behaviourists, with consultation by legal scholars.

- ‘Service Oriented Architecture’-paradigm in a military context.

  Explanation: concepts, models, techniques and tools building on structures, standards and insights from the business world to create an open environment where using cost-effective (external) services is an integral part of the business model for the creation, maintenance and deployment of military capabilities.

- Game theory-based models where agents with different value structures and outcome pay-offs collaborate; look for insights into effective teaming with “others”.

  Explanation: Although game theoretical models with 2 players competing are common, this TFA demands a number of players maximizing their utility against a constraint of a minimum satisfactory joint outcome. Meant to simulate how the military(s) must work with local governments, national governments, NGOs, religious leaders, etc.

- Legal and/or ethical research: Under what conditions do which set of laws prevail and what does this imply for contracted security, NATO forces and commercial logistics.

  Explanation: There may be some legal journal work on this, but little good guidance.

- Social networking as a means of reaching potential partners or niche providers.

  Explanation: Changing partners quickly means being connected. There may be some applicability of social network technology as a way of sorting through pre-qualified providers of a particular service as a way of looking for someone willing and able to partner. Think an organizational version of LinkedIn or something like that.

Solutions

- None identified.

H.9 CAPABLE OF DEFINING UNAMBIGUOUS RULES OF ENGAGEMENT (ROEs)

H.9.1 Theme-Issue-Capability Description

TIC 5.1.3 – Evolving Relationships between Man, Robotics and Machine Intelligence

The exponential increase in computing power over the coming decades will lead to advances in artificial intelligence and the increasing use of robotics in military operations. The removal of the 'man from the loop' has beneficial effects, but also leads to questions on how to incorporate these advances into military operations. In operations where concerns over fratricide, defective targeting and collateral damage may override effectiveness, reluctance to deploy autonomous weapons system may persist. These advances demand changes in other aspects of military planning and execution brought about by the increasing speed of action available to autonomous systems.

Issue – Moral, Ethical and Legal Considerations of "Human-out-of-the-Loop"

With the human out of the loop or not "at risk", the parameters for deciding on whether, where, when and how to wage war shift, at the political, strategically and operational/tactical level. What are the bounds/benefits of "automation" of military tasks? Winning the hearts and minds vs. safety of troops. Unmanned systems are typically used in dull, dirty or dangerous environments/tasks. Psychological/moral aspect – is escalation potential higher if technology substitutes personnel?

Capable of defining unambiguous Rules Of Engagement (ROEs).

H.9.2 JO 2030 Phase IV Out Reach Results

S16 – DRDC Office of the Chief Scientist Session 2

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Need new definitions:
  - What is a robot? Are clones impacted within this TIC?
  - What are legal orders? What is an autonomous system?
  - Wherein lies the balance between ethical, efficient and an effective robot?
- Challenges from engineering perspective:
  - How does one compute rules that distinguish human from robots, discern enemies that wish to surrender, while maintaining the ability to remove robots that are malfunctioning?
  - May need hierarchies of solutions with a master intelligence that coordinates subordinates.
- Robotic, Bayesian decision-making (Asimov, Bradbury or other):
  - In general ROEs are based on national laws.
  - NATO ROEs are not national.

Notes from Study Leader:

- Coding challenges:
  - Coding for 'values' – conflict between morality and immorality of war – coding for different national legal systems.

  - Coding for a peace mode, a security mode and a war mode – differing degrees of latitude and range of response accorded to the ‘machine.
  - Are today’s computer games already shifting the moral centre point?
  - Hierarchies of intelligence and protocols.
  - Can one code for trust, and other such characteristics?
- Need to define the balance point on ethical, efficient and effective.
- What unanticipated technology changes will force a change in today or tomorrow’s ROEs?
- Are clones also an issue in this TIC?
- What is a robot? What are legal orders? What is an autonomous system? Need definitions.
- Given the Pandora’s Box problem are there areas of investigation that should not be funded because their consequences are too risky or dangerous?

S17 – Kingston

Notes from Study Leader:

- Laws will generally follow the change.
- Arkin in George Tech – robots will be perform better than humans, robots should be shaped to serve humans – as AI advances we will want robots to work with a ‘value set’ that includes humans and doesn’t have room for attacking humans.
- Societal Rules that restrict and constrain the application of advancing tech, the citizen can’t buy armoured vehicles – except the laws and values in different countries.
- 10 years out we won’t accept that AI is at a stage that allows ‘trust’ in the robots.
- Laws and ethics and mores.
- Should there be ROEs for networks, are networks targets?
- War is a social engagement and is too important to be left to a machine.

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Human will remain in the loop as a policy statement. War is a social engagement and is too important to be left to a machine. Also if one took out the human to human engagement then one would take out the reason for war.
- Demonstrated taking an example from current commercial airplanes – have the ability for autopilot and yet two pilots are on board for take-off and landings.
- As AI advances we will want robots to work with a ‘value set’ that includes humans and doesn’t have room for attacking humans It is thought that by 2020 AI power would have the power to mimic human cognitive thinking.
- 10 years out we won’t accept that AI is at a stage that allows ‘trust’ in the robots. Also a question of reliability of a machine.
- Trust has always been an issue associated with technological development as in early trains there was a dead man switch built-in as a safeguard.
- Difference between virtual war and network war, i.e., cyber war vs. info-ops; e.g., Laws regulating second life now (laws generally follow the change).

- Team took it as a given that the ROEs developed would be ambiguous since ROEs evolve from social norms – going through domestic filters and ethical conditioning of the times and then come laws.
- **Closing thought**: If we are to survive our autonomous systems then these systems have to be human-friendly and support man, which in turn, creates other dilemmas such as security (European PhD thesis on how humans of the future may have to rely on robots to proliferate) therefore ROEs would have to have the human in the loop.

S22 – DRDC Suffield

Notes from Study Leader:

- Does this move mutual assured destruction back in the game?
- Are we more likely to engage or go into places we wouldn't otherwise go to?
- Is there risk of moral drift?
- Does an unmanned force make some decisions easier to make?

Technology Focus Areas

- Different decision-making approaches – robotic, Boolean, Bayesian.
- Coding values such as loyalty or trust in autonomous systems, coding for different value sets or laws for different Nations or situations.
- Which programs should not be researched because they are inherently too dangerous?
- Can the legal and ethical world anticipate the coming technology challenges and changes or only lag them?

H.9.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Moral issues in the use of autonomous systems: The most morally and legally difficult issues with rules of engagement usually pertain to the use of force. Rules of engagement are often mechanisms for constraining our employment of force, whilst ensuring that we do not accept significant risk of harm to our own forces or other third parties. A moral issue was raised – there is clearly a reduced risk of harm to our own forces when we employ autonomous systems, since they are now systems, rather than people, which has implications for the employment of violence and our rules of engagement. The element of the rule of engagement vested in "self-defence" is weakened.
- Trust in autonomous systems: There remains significant scepticism concerning the use of autonomy across the full range of military tasks. Issues of trust and precedents were discussed. There was considerable interest in supervised autonomy, a concept whereby autonomous systems would seek confirmation from a person in the event of making a significant or irrecoverable decision (e.g., to attack something). A route map could be developed that would indicate growing acceptance within the population about the use of autonomous systems. The route map could be considered in 2D, where Y-axis comprised of Sheridan's (1994) ten levels of human supervisory control and the X-axis comprised of the range of tasks undertaken by an autonomous systems. Key precedents could be identified across the area, which might include, for example:
  - Autonomy in passenger vehicle control; and
  - Autonomy in the use of autonomous systems in medical science.

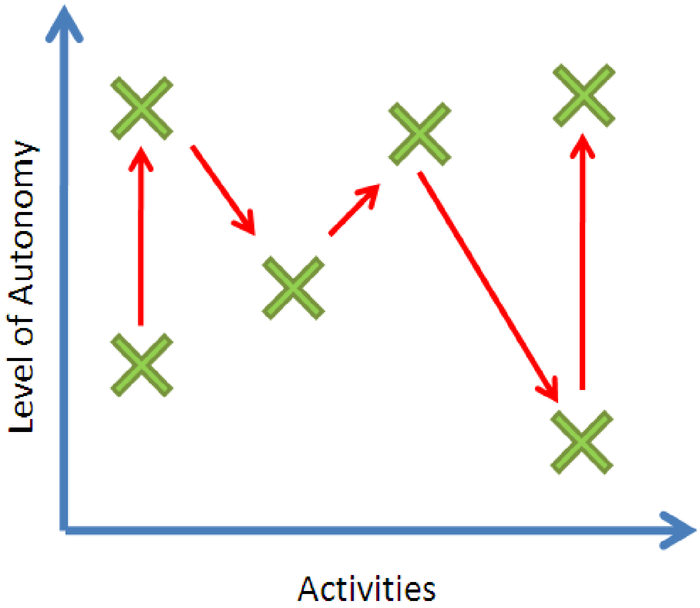

Figure H-1: Example Route Map of Levels of Autonomy and Activity.

Technology Focus Areas

- **Information Flow**: Need to improve man-machine and machine-machine interfaces.
- **Information Quality in Autonomous Decision-Making**: Constraining potential courses of action for autonomous systems depending on the availability and quality of information. Medium Importance. Investigate decision-making algorithms – investigate Weick's on sensemaking and the effect of information (quantity and quality) on decision-making.

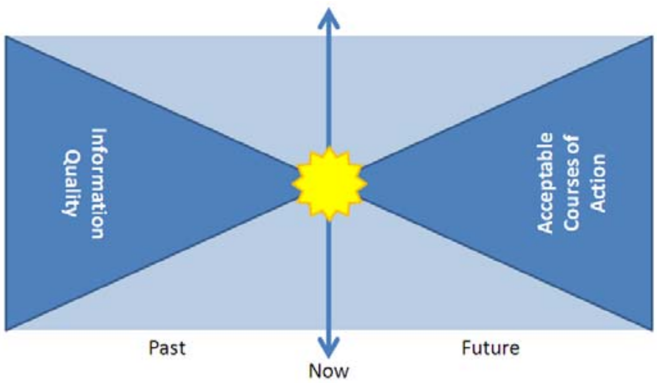

Figure H-2: Minkowski Diagram of Constrained Courses of Action.

- **Improving Bandwidth Availability**: Most autonomous systems will require a capability to communicate remotely. It was considered highly likely that future autonomous systems would include distributed versions, which was called the 'Hub-Brain' concept. The Hub-Brain would be the expensive, vulnerable element of the autonomous system, which would network to cheaper elements that would be employed directly into action. High importance. Investigate the state-of-the-art research on bandwidth improvements. To include the "White Realm", "Photonic", and "Cognitive Radio" concepts.

- **Dominating Bandwidth Availability**: Given an assumption of continuing problems with supply and demand of bandwidth, the possibility of a capability that would buy-up available bandwidth was identified. Of medium importance. Investigate options for dominating the bandwidth spot-market.
- **Minimum Regret Rules of Engagement for Autonomous Systems**: The important of maintaining the trust of the population in the employment of fully autonomous systems will be essential. The recommendation was that autonomous systems should employ rules of engagement that minimise the probability of making an error, as opposed to maximising the probability of making the right decision (see: confusion matrices). Of medium importance. Investigate implications of min-regret rules of engagement for autonomous systems.
- **Verification and Validation of Complex Systems**: Assuming that autonomous systems are likely to be learning, employing self-generated code, and be employed in complex, open situations, then the verification and validation will pose significant issues. Firstly, the employment of existing verification and validation practice, testing a mature set of code against a specified list of requirements is likely to be invalid (since the code is likely to be dynamic) and even is the code were frozen, the combination of the complexity of the code with the range of potential situations would likely render verification and validation impractical. Of high importance:
  - Investigate real-time verification and validation, where a representation of the system is simulated in real-time milliseconds ahead of reality and the resultant actions are scrutinised.
  - Investigate “Adjustable Autonomous Policy Management” in which policies are verified and validated and an autonomous system’s transition between policies is monitored and controlled.

Solutions

- None identified.

H.10 CAPABLE OF DEVELOPING FLEXIBLE AND ADAPTIVE LEADERS

H.10.1 Theme-Issue-Capability Description

TIC 6.3.5 – Staying Power

It seems probable in the coming decades that Alliance military forces will be engaged on a more or less continuous basis in operations requiring significant numbers of the troops and weapons systems. To successful undertake such operations over time will require ‘staying power’ from Alliance Nations to remain engaged. There is a perception that Alliance forces currently do not possess sufficient staying power to engage a tenacious, adaptive enemy that seeks to keep Alliance forces engaged for a long period. Staying power must be developed at several conceptual levels:

- Political – political priorities and messages must be aligned to keep forces engaged.
- Operational – clever campaign design, use of technology, avoidance of too ambitious operations and increased forces.
- Tactical – operations are typically undertaken by small units demanding improved equipment, protection and tactics.

Issue – Establish a Workable Division of Labour / Collaboration Structure with Other Agencies

Both with other governmental agencies, with NGOs and with private parties. In various forms of partnerships or customer-contractor relationships. Typically in prolonged stabilisation and reconstruction endeavours.

It should be noted that the ‘civil-military loop’ implied here goes beyond what is currently understood under the term ‘CIMIC’ (Civil-Military Cooperation). CIMIC is an instrument for the military Commander, basically aimed at force protection and accomplishment of the military mission. The civil-military interaction here is aimed at achieving a higher order objective and is not ‘owned’ by the military.

Capable of developing flexible and adaptive leaders.

H.10.2 JO 2030 Phase IV Out Reach Results

S20 – Canadian Forces Directorate of Future Security Analysis

Notes from Study Leader:

- Related to power and national influence.
- CIMIC only means something to the military world.
- Who ‘owns’ what is a sticking point – and is a command and control challenge?
- Flexible leaders need an organization that supports a flexible leader – incentive structure – need different organizational and cultural constructs.
- Politics and politicians – lack knowledge and experience.
- The Canadian Public Service doesn’t develop leaders it develops managers.
- Need more cross-training/posting/pollination/exposure.

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Developing leadership vs. developing leaders are two different things.
- Need to develop a creative framework that will allow people/leaders to be flexible. Will need to examine the incentive structure.
- While Command and control are military terms, they are seen as ‘bad’ words by other civil organizations (within the Government as well as NGOs) Distinctions between CIDA and DFAIT will be blurred in 2030 and hence sometimes the military are the military support units and at other times will be supporting civil organizations.
- For a non-comprehensive/non-systematic system, the only place one gets trained to from Day 1 to conduct a mission is within the military. Military tasking regime built over 150 years.
- The public service develops managers not leaders, business people that drive economy are leaders and the business community does not come by leaders through education. The military the only organization that is structured to develop leaders, perhaps the military model can be used to develop leaders in non-military organizations.
- In this capability, the word flexible is the one that is problematic, if one removes flexible then adaptive leaders is what the military develops, i.e., adaptive to the condition-set one is within.
- Flexible implies consensus. Eisenhower was able to stay on message as he did not take in consensus.
- In a comprehensive approach, partners are necessary and will require respect.

S22 – DRDC Suffield

Notes from Study Leader:

- How do you ‘lead’ robots – are robots independent or under many layers of control?

Technology Focus Areas

- Extra-organisational relationship studies.
- Organizational studies; clash between value set of a C2 organization and a collaborate and consensus organization.
- How will autonomous units or robots be led?

H.10.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Leaders ≠ leadership.
- 2 Dimensions – military vulnerable on civilian tech (viruses), others using civilian to attack (Al Qaeda).
- Different forms of leadership under different conditions.
- Strategic Corporal – strategic citizen.
- Evolving leadership – ‘able to rapidly shift plans/ideas’.
- Leaders in peer-to-peer environment.
- Civil-military leadership training (common education).
- Different types of leadership for different types of mission?

- Let leaders fail (and learn from it).
- Different dimensions/levels of leadership.
- (Changing) definition of leadership.
- Hierarchical leadership (not ONE leader but leaders in different domain within different domains) / away from single ‘heroic’ leadership.
- Distributed leadership.
- Countering “10-USD soldiers” by providing “15-USD local service providers” on a win-win basis.
- Emergence and leadership – emergent leadership and leading emergence.
- Find a solution to overlapping ‘enemy/adversary’ communities.
- Promote multi-racial politics / cultural leaders, able to integrate different cultures, religions, etc.
- Set up old administration of indigenous affairs like in Africa and Middle East (social networks based on indigenous society’s knowledge).
- Role of media.
- History of leadership.
- Do robots need leaders/leadership? Should specialized robots choose their missions?
- Hybrid training – military-type training model of developing leaders being extended to universities.
- Exchange of leaders for exercises (military and NGO, Police, etc.).
- Use more methods of managements from commercial sphere.
- Train leaders for ‘centralized control / decentralized execution’.
- Framework for career progression (include incentives for demonstrating leadership).
- Lateral entry (other leaders entering the military).
- Career flexibility – military leaders encouraged to exercise leadership roles in other settings (business, police, etc.).

Technology Focus Areas

- Virtual reality.
- Organizational theory.
- Social psychology (types of leadership) – transformational, transactional, authoritarian, charismatic.
- Knowledge management methods and tools.
- Community of practice websites (e.g., US Army Captain’s website).
- Decision-making support (knowledge / data sharing).
- Interest prediction.
- Cooperation opportunity identification.

Solutions

- None identified.

H.11 CAPABLE OF ADAPTING ORGANIZATIONAL STRUCTURES TO REFLECT CHANGING CIRCUMSTANCES AND EVOLVING OBJECTIVES

H.11.1 Theme-Issue-Capability Description

TIC 7.3.4 – Small Teams Operations

In the future, military operations will increasingly be the domain of small units and teams. This will include variants of small fighting units and multi-disciplinary teams designed to address specific multi-faceted problems where security only forms part of the puzzle. These teams must generally work autonomous, independent operations for considerable periods of time. These teams must be able to shape the 'command intent' to develop solutions based on local conditions. They must be to 'sense and respond' independent of the larger force and adapt accordingly. This will drive modularity and networked requirements.

Issue – Quick Organisational Learning Cycle

Quickly promulgate locally learned lessons to other relevant parts of the organisation. Both to dampen out tried-out but proven ineffective strategies and to amplify effective emergent strategies. Sharing of 'situational understanding' to achieve coherent effects that are realistic in the given situation.

Capable of adapting organizational structures to reflect changing circumstances and evolving objectives.

H.11.2 JO 2030 Phase IV Out Reach Results

S11 – Brussels

Notes from LtCol. Christian Micha:

How would you describe a possible solution or solution approach for the capability in the context of the Issue in the 2030 time frame?

- The problems are situated in the field of human and material resources:
  - Human resources – the reconfiguration of the Armed Forces, the recruitment of suitable staff (active recruitment), as well as the cooperation with specific agents (e.g., NGO).
  - Material resources – the importance of the material characteristics of compactness, minimal weight and miniaturization.
  - The use of intelligent robots as "carrier".
  - The use of miniature weapon systems.
- To reason from the perspective of a small team concept implies focusing the attention to a nucleus which will be supplemented depending on the specific mission small teams always operate in a network and depend on adequate information. The technological requirements are as follows:
  - A reconfigurable network depending on the objectives.
  - High level fusion – tools for the processing of heterogeneous data into meaningful data to allow for adequate decision-making.

    - Data mining – generating correct information from a multiplicity of data.
    - Adaptability of databases.
    - Sensors for intelligence.

- The human factor will be the critical factor. Traditional recruitment in an already limited labour market will not suffice to meet the specific staff requirements. The staff will have to dispose of particular capabilities (cognitive, open mindset, culturally sensitive, etc.). Possible solution strategies would be:
    - Enhance the attractiveness of defence as a potential employer.
    - Active recruitment.
    - Training courses to develop the necessary skills.
    - Specialise the soldier or militarise the specialist.

Is there a "roadmap" to your solution ("things already in the "pipeline", enablers, drivers, required technologies, critical points)?

- Owing to the technological evolution and the changes in concept building the required cultural turnover has set in:
    - Various applications of nanotechnology (e.g., intelligent clothing).
    - Miniaturization of existing materials.
    - Concept of 'dismounted soldier'.
    - Weight redundancy functioning and operating.
    - Sensors.

- The work group discerns two critical aspects:
    - The necessity of an open mind set in the organization as a whole.
    - The significance of cooperation, the necessity of getting acquainted – the development of social skills and a team spirit are crucial to the effectiveness of small teams.
    - Remark – a team is more than the sum total of the individuals.

- In the future some tasks of small teams are likely to be taken over by robots.

- The current leadership concept is probably obsolete. One should rather think in terms of a coordinator who is capable of motivating and guiding specialised co-workers. The material used during military operations must not deter the local population. As such a laptop may well provoke resistance with backward/underdeveloped sections of the population. The primary aim is to meet people.

Are you aware of institutions/people already working on solutions to this capability requirement?

- In the field of sensors – SET Panel of NATO.
- Small teams is not a focus of research in the HFM Panel of NATO, however, this option should always be left open.

At the end of this brainstorming session the following conclusions were added:

- A positive ascertainment is the already existing tendency within NATO to give small teams a more predominant position from both the reflexive and capabilities point of view.

- The specific character of the current and future military operations will, for that matter, reinforce this tendency.
- National armies still have a long way to go to implement the transition from a conventional structure to small teams.

S22 – DRDC Suffield

Notes from Study Leader:

- Legality of leasing of assets.
- Grunts are becoming knowledge workers.
- Heterogeneous robotic teams.

S24 – DRDC Toronto

Notes from Study Leader:

- Flexible command structure – modularity of structure.

Technology Focus Areas

- Data Fusion.
- Evolving place and role of military organizations in relation to the societies or Nations they support.
- Evolving command structures, information flow patterns, and levels of decision-making.

H.11.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Systems concept for generating lessons learnt for future small units using narratives – description of the concept:
  - "In a remote part of Africa, a small team of NATO operators arrived at a village for a meeting with an important tribal elder. As part of his preparations, the leader of the team spent the previous evening in an immersive virtual reality which included recommended narratives to employ.
  - During the meeting, sensors and other systems collected information on the environment, including body language, olfactory, aural, and other forensic information. At the after action review, these data along with assessments of the meeting from both team members and remotely by subject matter experts are packaged and sent to a remote analysis centre at NATO Headquarters. A set of contextual metadata was generated automatically and associated with the data packet.
  - A few hours later, an analysis team comes together to discuss the meeting with the tribal elder. They extract lessons learnt from the event discuss the efficacy of the tactics employed and use models and simulation to assess the utility of lessons learnt across the wider force and to identify whether they need to update the master lessons learnt database. In the meantime, the analysis centre notes that another team is preparing to meet with a local politician in South America; an appropriate set of lessons learnt are selected, packaged, and prepared to be issued. Before the lessons learnt are sent to the team in South America, the production facility takes the images and video footage from the generic lessons learnt and modifies it to match a South American context – what was footage of a meeting in a mud-hut with an African tribal

leader becomes footage of a meeting in a jungle clearing with a South American Indian, the soundtrack is modified, languages and background noises changed, smells are added.

- The product is reviewed, added to the master database and then squirted to the team for its morning preparatory meeting."

Technology Focus Areas

- Environmental Data Collection – The small units will passively absorb and actively collect enormous amounts of environmental data. The data collection must span the range of human senses (most importantly sight, sound, and smell), data collection might include forensic (own and others) and the automatic generation of appropriate meta-data to enable analysis and post action use. Of high importance:
  - Systems that are able to actively and passively collect sensory and other data that will form the kernel of the critical event assessment packet.
  - Miniaturisation?
- Critical Event Assessment – Small units will need to receive timely assessments of the effect of engagements (here an engagement is defined as the employment of a small unit in a discrete task, for example, a meeting with a key-leader, foot patrol, combat action, food distribution in a village, etc.) Analogous to battlefield damage assessments, this critical event assessment requires a near-real-time generation of a classification of the event, an assessment of the outcome (partially autonomous), then automatic archiving with appropriate metadata to enable its retrieval. The critical event assessment will include a bundled packet of sensory inputs (video, audio, etc.). Of high importance:
  - Identifying appropriate metrics for the assessment of the event.
  - Identifying ontology and taxonomies for metadata for classifying and archiving the event.
- Remote Analysis Centre – The remote analysis centre is responsible for receiving the critical event assessment packets and analysing them. The centre combines a wide range of experts who will develop lessons learnt from the critical event assessment packet. The centre undertakes analysis of the lessons learnt to characterise them for future use. Of high importance:
  - Analysis of critical events for lessons learnt using a broad range of subject matter experts.
  - Archiving and maintaining a library of critical events.
  - Developing models to assess the lessons learnt events in order to determine their generic applicability.
- Production Facility – The production facility is responsible for generating a bespoke product that meets the needs of each small unit. Using data mining (and other search techniques) the production facility captures the lessons learnt that are a best fit for each team and post-processes the generic lessons learnt to ensure that they meet the contextual requirements of the small unit and are in an appropriate format. Of high importance:
  - Systems to artificially manipulate imagery and other supporting elements of the lesson learnt packet.
  - Generate lessons learnt format requirements.
  - Systems to generate extrapolations from lessons learnt.
- Distribution – The bespoke lessons learnt are distributed to the small teams in a timely manner. Careful consideration is given to the extent of the distribution, balancing the level of the distribution

against the need for not overloading the individual members of the team. Lessons are provided in a format and manner that is a best for the small team – which might require a variety of formats and playback capabilities. Of high importance:

- Systems to distribute lessons learnt in a timely manner.
- Systems to receive the lessons learnt and broadcast it to the small unit or unit members.

- Implementation – The lessons learnt arrive at the small unit where they are added to a lessons learned repository for team viewing or to individuals depending on lesson and individual needs. Of high importance:
  - Systems to monitor the use of the lessons learnt.
  - Systems to monitor the effectiveness of the implementation of lessons learnt and to provide prompt feedback to the remote analysis centre.

Solutions

- None identified.

H.12 CAPABLE OF GATHERING, ANALYSING AND DISSEMINATING LESSONS LEARNED IN A TIMELY FASHION

H.12.1 Theme-Issue-Capability Description

TIC 8.1.2 – Strategic Compression

Strategic compression can be defined as the forming of unexpected casual relationships and breaking of expected causal relationships among the tactical, operational and strategic levels of conflict in the political, information, military and economic domains. This is a combination of the 'strategic Corporal' and the 'tactical politician'. This is brought about by the interconnectedness of the globalised environment and the pervasiveness of the 24-hour media cycle supported by almost instantaneous information systems and networks allowing more people access to more information. The coalition nature of most future operations will increase the importance of controlling strategic compression to maintain the coherence/viability of the coalition.

Issue – Different Causal Relationships Across the Levels of Conflict/Organisations/ Endeavours

Strategic compression is the forming of unexpected or breaking of expected causal relationships among the tactical, operational and strategic level of conflict, of organisations and of endeavours (operations). Both the broadening of the types of endeavours where the military have a role and the increased complexity of typical endeavours cause this phenomenon. How to organise tasks, competences, responsibilities and available resources to mirror the reality of strategic compression? How to deal with strategic Corporals and tactical Generals / micro management? How do accountability and media coverage/pressure affect the Issue?

Capable of gathering, analysing and disseminating lessons learned in a timely fashion.

H.12.2 JO 2030 Phase IV Out Reach Results

S17 – Kingston

Notes from Study Leader:

- For example the Company Commander.com web site (http://companycommand.army.mil/index.htm) – which is an example of peer-to-peer social networking and collaboration.
- Current mil construct works to stifle and suppress innovation and initiative.
- In Afghanistan 20 patrols, which one has the strategic Corporal – all the Corporals think they are important and think they should be in the General's head.
- While the Corporal can be strategic given the right time and place who can know or shape that in advance.
- UAV operators launching a strike are suffering the highest PTSD.
- In 2030 how do lessons learned differ from changing situational awareness?
- My Lai massacre – who is going to codify the hunch? We will be reluctant to trust the machine.

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Intelligent communication – push vs. pull – without overwhelming the user; e.g., transition from email (which is now passé) to twitter, etc.

- Tactical General can have his hand on the pulse of a strategic Corporal through technology networks, only when it makes sense to do so.
- Machine can do or facilitate all these functions.
- Reluctant to let the machine do everything because of trust issues even though.
- Human in the loop can delay the decision-making.
- Through technology the decision-making process time could be compressed yet there is danger of information overload.
- In 2030, will there still be a difference between situational awareness and lessons learned? (The latter implies a lag.)
- Not until the human is being augmented/enhanced. Blink Gladwell's book firemen and floor – difference between conscious and subconscious is intuition. Can build reflexes and intuition, hence the military trains and does drills – train to respond and reduce the time taken for decision-making.
- In 2030 Sit awareness and lessons learned will merge and reduce the feedback loop timing.
- References:
  - Blink – M. Gladwell.
  - America's army (most downloaded video game – a recruiting tool.

Technology Focus Areas

- Role and impact of evolving social networking paradigms.

H.12.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Two loops, one fast with info back to operations and the second with a time delay enabling time to evaluate different technical solutions and then send back to troops.
- Validation and sorting of excess information; speed vs. quality.
- How does one deal with classified and security issues? Simulation of lessons ('push' lessons learned) practice.
- Lessons-used technology required, not just lessons identified or even learned.
- Knowledge – formal (databases) AND tacit (real people).
- Sharer concepts.
- Time – search issue, ontology, feedback.
- Standards for representation and exchange of lessons learned for building repositories.
- Multi-level analysis of after-action reports.
- Dynamic exploitation of lessons learned for planning of ops.
- Automation – to search; to go back to decision-making; use human preferences.
- Google's motto – "Search, don't sort."
- Wiki's (lessons learned feeding directly into doctrine).
- Tacit knowledge must be transferred as well – sandboxes, simulation Workshops and non-formal methods (bar, coffee, smokers).

- Need multi-national exercises to ensure transfer of knowledge.
- Lessons evangelists (Apple).
- Education infrastructure.
- Call previous unit/Commander to find out what they learned.
- Learn from private sector (e.g., social networking business).
- Hiring cultural ‘translators’ (Google, HSBC, Scandia).
- Doesn’t matter about security – other side can learn too; speed of execution and affinity is more important.
- Raise entry-level standards for military personnel – requires many changes too.
- Retirement of knowledge – doesn’t happen; requires practice of new knowledge.
- Training in writing lessons learned.
- Main principle – unit of command.
- Knowledge management (e.g., fora and helpdesks for tech/software help).

Technology Focus Areas

- Transformation of voice into a written reports database.
- Automatic ontology generation where there is a distinction between search and sort ontologies for data mining.
- Knowledge representation (including time history of info/knowledge).
- Ontologies to help relate lessons learned with other information (planning, situational awareness).
- AI for automated extraction of lessons learned.
- Multi-level analysis search engine for visual info.
- Capturing of voice reports into written reports database, with automatic keywords recording for later extraction.
- Lessons learned database – TFA extraction out of database (now search engine triggered by text; future – search engine triggered by voice (/brain)).
- Visualization.
- Data- mining speech to text linked with videos.
- Automated data mining through algorithms.
- Social networking for lessons learned.

Solutions

- None identified.

H.13 CAPABLE OF EMPOWERING SOCIETY / LOCAL COMMUNITIES TO DEAL WITH THE RISKS ASSOCIATED WITH THE PROLIFERATION OF DUAL-USE TECHNOLOGY

H.13.1 Theme-Issue-Capability Description

TIC 9.2.2 – Dual-Use Technology

The concept of dual-use technology has most recently been used to describe the use of commercial technology for military purposes. With the bulk of research and development funds being expended on commercial development of technology, it very likely such developments will produce systems that will have a collateral military use. As scientific advances increase exponentially over the coming decades, there will be a requirement to monitor commercial technology for those developments that could give possible adversaries a mechanism to produce weapons systems.

Issue – Pace of Technology Development

The pace of technology development is accelerating with a big jump ahead through the combination of advances in ICT, nano and bio technology and cognitive sciences. The variety of ways to wage war may drastically increase – faster than society can keep up in terms of legal and moral embedding of the phenomenon of war.

Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology.

H.13.2 JO 2030 Phase IV Out Reach Results

S13 – DRDC Office of the Chief Scientist Session 1

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Resilience engineering.
- Help to ensure that Innovation remains ahead of the curve.
- Low tech solution back-ups.
- Build systems that sense, detect and prevent infiltration of infrastructure including border controls, surveillance of food and fuel supply or biological moles.
- Diversify systems.
- Make systems more flexible, agile and adaptable.
- At least for critical vulnerable points within infrastructure systems.
- Maintain technology outlook of human susceptibility and gene manipulation.
- Use information operations to counter S&T leakage.
- Mobilize scientific communities to monitor dual-use developments.
- Have a large set of solutions that are broadly defined.
- Conduct ongoing literature reviews, learn from history.
- Localized weather control systems.

- Strengthening regulatory frameworks.
- Build legal and ethical frameworks with built-in agility and the ability to adapt to respond.
- Nature’s solution – Initiating survival of the fittest.
- Build human networks.
- Have a technology ‘First Responder Network’.
- Develop and maintain database for technological and human resources.

S17 – Kingston

Notes from Study Leader:

- Military procurement lags acquisition of new tech. – new technology – the Red Team may in fact often have the advantage in many of the capability demands.
- Blue force tracking in a cell phone, differing levels of robustness.
- Design systems to be upgraded vice being replaced.
- Society is empowered by the web and all that it informs – this is a good thing and an enduring reality going forward.
- Empowering the society is not the solution – how will the military deal with rapid commercial tech development.
- Exploit the ‘open’ environment open standards, etc.
- Building and maintain good will and trust, the greater this is done the less the propensity to abuse dual-use tech.

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Each step forward is another step in need of a counter step. Each tech advance has both a peaceful and violent potential use – multi-functional and multi-exploitable.
- Dual-use seen more as a security risk for the military.
- Not empowering the society as society already is ahead and has access to the technology before the military.
- How does the military community harness the power of commercial technologies?
- Speed up the acquisition loop for the mil.
- Work to speed up acquisition, to accept more risk and shorter equipment life spans this can’t be said often enough; Blue force tracking in a cell phone, differing levels of robustness; as currently commercially available used for tracking children but not spoof-proof.
- Design systems to be upgradeable, i.e., build-in agility.
- More collaboration between civilians and def and vice versa.
- Society is empowered by the web and all that it informs; this is a good thing and an enduring reality going forward.
- Open collaborations, social networking, internet, etc., facilitates societal empowerment for ‘Do-it-Yourself’ projects– even $1500 gyroscopes.
- Empowering the society is not the solution – how will the military deal with rapid commercial tech development.

S18 – DRDC Ottawa

Notes from Study Leader:

- Leveraging COTS for military purposes.
- Commercial world often leads military in many technologies.
- Need to imbed people and quality in the production process.
- Shifts in company loyalty and trends in industrial espionage.
- Off-shore production in the global economy = loss of control.
- Life cycle issues, legacy systems, repair by replace.

S22 – DRDC Suffield

Notes from Study Leader:

- Tracking and monitoring the transfer of nucleotide base strings – why track the bug when you can get the gene?
- Common cell phones could have a dual use in robotic control.
- iPhone vs. UAV autopilot controls – many similarities but not as simple as it looks.
- Exploit the steps of industry.

S25 – NIAG Rome #2

Summary of Results from this Solution Solicitation Session.

INTRODUCTION

Consistent with the agenda the Workshop has been organised in two phases.

The first phase was dedicated to presentations prepared by selected experts of Italian Industries who have been invited to examine a TIC selected beforehand among the 40 on the basis of the industrial expertise.

The TIC under examination is the 9.2.2 that refers to the opportunity to adopt for Defence products and services high quality innovation from the COTS technology at reasonable costs.

THEME	ISSUE	CAPABILITY
Dual-Use Technology (COTS)	Spin-in of high quality, high pace innovation	Capable of measuring, analysing, predicting and anticipating risk within a complex environment

The participants to the Workshop were asked to explain their point of view in accordance with the fields of interest of their companies.

A second phase was devoted to a classical discussion session to provide answers to the following questions:

1) How advancement in civil domains can be spin-in effectively in the military domain.
2) How to guarantee security of information and security of supply.
3) What is needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications.

4) How the adoption of the dual-use technology, combined with the industrial expertise and high quality military professional skill, can confer to the West a competitive edge.

THE PRESENTATIONS

A summary of the presentations offered by the participants to the S3 follows this report.

SYNTHESIS OF THE PRESENTATIONS CONTENTS

The first presentation points out that the experienced use of the commercial technologies is a factor of success for defence and security systems. The most part of this technology is in the field of electronics that is fundamental for all the platforms. In particular it is a key element of system-of-systems which integrates all the Armed Forces assets, making them potentially interoperable with those of other Armed Forces for coalition operations.

The communication sector is a meaningful example of adoption of dual-use basic technologies always more developed in the civilian sphere and applied to military and institutional markets, often adopting the same equipments. In this field a growth of opportunities is driven by the IP and software-like technologies.

Another sector where dual-use technologies are applied is the aeronautics with always less distinction between military and civilian aviation through innovative proprietary manufacturing processes.

As a general statement the author claims that in this sector as in others it is very important the exchange of experience, knowledge and processes between the civilian and the military sectors.

The second speech dealt with future military system-of-systems such as NCW and NCO which are underpinned by new emerging communication technologies which are very common to civilian applications.

In the future this situation will become always more heightened.

All the new boundaries that are opening with internet usage lead to the definition of the "internet of the future". The Web will allow interactions among the users by integrating the technologies of semantic Web with the pervasive computing, ambient intelligence and service-oriented components.

The SDR will be the dual use par excellence in the communication field which, in order to be used for sensitive data, will be equipped with cryptographic keys for maximum of security of the flowing data, keys that by means of a mechanism of asymmetric cryptography cannot be modified.

The third presentation refers to Internet technology that will be used to deliver to external customers a scalable and elastic information technology service obtained by a cloud computing. Dual use is possible by means of:

- Segregated internet-based infrastructure;
- Scalable and elastic infrastructure;
- Shared pool of resources to deliver the services;
- Services available on the infrastructure to authorized users;
- Services and users interface through well-defined infrastructures; and
- Technology adapts to the needs of the services and the users.

The fourth presentation is an examination of the space services. There is no specific differentiation on technologies for military and civilian use; the difference is mainly on the way they are used to develop specific solutions/applications.

Applications are sometime complementary, especially in the domain of “security”, also induced by the strict cooperation between civilian/military governmental institutions on “crisis management”.

SPACE is widely recognized a critical enabler for security and defence but as NATO currently does not have a space policy or space strategy there is a need to better integrate national space capabilities in order to be able to conduct combined space operations.

Opportunities are the dual-use synergies and the interoperability with civilian systems.

The technology of the swarms of robots is tackled in the fifth delivery.

The need to protect sensitive areas, both military and civil, key objective in several critical scenarios, such as:

- peacekeeping missions,
- surveillance,
- homeland security,
- dual-use missions,

requires new paradigms to design distributed, cooperative systems which adaptively cope with external and internal changes.

The future scenario foresees increase in mission complexity, to be managed via ad hoc available resources both civilian and military.

The systems must be capable to understand the operational context and autonomously act accordingly.

The huge amount of contextual information in dual-use pervasive environment makes existing systems often inefficient, even useless.

Cooperating agents and pervasive reasoning are the means to overcome these limits.

The underpinning dual-use technologies (2030) are for the cooperating agents the biotechnologies, nanotechnologies and robotics and for the pervasive reasoning some key SW technologies such as information assurance mechanisms and real-time middleware for micro/nano platforms and the biological inspired reasoning.

The sixth speech examined the current and next future use of civilian (COTS) technology in the military EW domain, which is currently perceived as an opportunity at the initial acquisition and can become an issue during the operational life of novel military equipment.

The unavailability of some obsolete component within a board or module of equipment implies that the latter cannot be repaired in case of failure. This issue is usually solved according to two alternatives:

- Last Time Buy (LTB) of obsolete components; and
- FFF (Form Fit Function) re-design of the board/module comprising the obsolete component.

The first solution is usually applied in the case of a limited series production as the cost of the buy and stock is still convenient.

The second solution is instead applied in the case of series production prolonged in time usually a large number of equipments).

The methodology used by Elettronica for the second solution is briefly reported in the presentation.

Pros and cons of the dual-use technology in the military C2 systems are proposed in the seventh presentation. In fact technologies that are very popular in the civilian domain are becoming popular in C2 Systems too, namely:

- Internet technology (networking, grid/cloud computing);
- Web portal technology (integration of applications);
- GIS, 3D visualisation tools (scenario representation);
- Modelling and simulation tools (e.g., serious gaming); and
- Logistic information systems.

Dual-use technology provides an opportunity to import high quality innovation at reasonable costs for business processes, products and services.

This is expected to have a positive impact, mainly in terms of cost and deployment time, new and enhanced functionality, interoperability, workload, reaction times, standardisation.

As for or all these technologies the leadership is clearly in the civilian domain because of the market share and devoted R&D investments, the dual-use technology implies risks that must be tackled and solved.

These risks include adaptation to military requirements and security of information.

Integration with defence specific technologies is still required for efficient and effective (large scale) military applications but civilian solutions have often a limited possibility of customisation.

Moreover the rapid evolution and openness of the technology makes it very difficult to maintain a technological dominance.

Security of supply, lack of stability, difficult to have long-term commitment for maintenance is other subjects that need a parallel mitigation effort.

The eighth lecture is an introduction to System-of-Systems (SoS) which are “super-system” inclusive of elements which are themselves complex, independent systems interacting to achieve a common goal.

In a system-of-systems the resultant operational function is equal or better than the sum of the operational functions of the single components (only for Hetero SoS and only if signals fusion is accomplished).

Being SoS the new frontier, innovative technologies are required which imply creative destruction, multi-disciplinary approaches, a new “mind-set and time, cost, risk.

The author affirms that large complex systems both for civilian and military applications are a new frontier that needs new approaches and paradigms for ICT and SW such as the ones adopted by the Open Society Institute, or by open source constructs (Linux, Google, Twitter, Ecosystem, Internet, etc.) that can be considered a dual-use technology.

The results of a pertinent EDA study (DISCOTECH) on dual-use technology are listed in the ninth presentation. The study establishes roadmaps for European technology investments in electronic and photonic component technology development for military use, covering the coming 10 years.

Subjects covered by the study:

- Forecast of COTS developments;

- Identification of areas where COTS components will not be sufficient for the needs of the military user; and
- Establishment of roadmaps for European investments in component development for the military user.

The study has identified where COTS may be used for military application and where European investments are needed because:

- The COTS may need extensive adaptation;
- The COTS product and technology will not be available in due time with regards to application;
- The technologies need a breakthrough which COTS cannot bring;
- Security or limitations of supply chain; and
- ITAR and EAR limitations.

Finally some disruptive technologies which can have impacts both on the civilian and military field have been proposed for discussion.

A disruptive technology is defined as a technology with the potential to causes a noticeable – even if temporary – degradation or enhancement in one of the elements of US national power (geopolitical, military, economic, or social cohesion).

The examined ones are:

- Biogerontechnology;
- Energy storage technologies;
- Biofuels and bio-based chemicals production technologies;
- Clean coal technologies and an array of related technologies; and
- Robots.

By 2025 Internet nodes may reside in everyday things.

A brief description of these technologies taken from internet is contained in the annexes.

BREAK OUT SESSION

The presentations content is itself exhaustive as far as the analysis of the dual-use technologies, their implications when used in the military field and the sagacity to be used in order not to run into trouble once adopted into equipment, systems and system-of-systems.

In other words the strategy says that the adoption of the dual-use technologies is inevitable for different reasons essentially in areas where the civilian investments have brought to solutions with no other proprietary alternatives.

The tactics calls for the establishment of mitigation factors that allows bypassing the problem once it occurs.

So the answer to the first questions "How advancement in civil domains can be spin-in effectively in the military domain" is that the operational requirements are always assigned to the military domain; the dual-use technology is a practicable solution provided that it is dominated in all its peculiarities.

About "How to guarantee security of information and security of supply" there are specific answers in the presentations that can be condensed in these rules – capability to create substitutes in the hardware environment and solutions to protect the information in the informatics network. The latter applies even more in the communication domain where hardware and software of the infrastructures can be dual but where the solutions inherent to security have to remain under complete control of the military jurisdiction.

As far as "What is needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications" the working group is convinced that defence (military domain) and security (civilian domain) are aligned, so the basic architectural configurations of the relevant systems are very similar both for the sensory and information services. The remaining defence specific technologies should be conceived in order to match as much as possible the acquired dual-use solutions.

Anyhow the defence domain is different from the commercial one and then the rules of costs lowering by means of the market globalisation are not applicable as it is. The world of defence needs to acquire and maintain strategic advantages through the control of specific technological sources.

Then the COTS solutions can represent an opportunity but they cannot substitute completely the key and strategic technologies whose control represents a winning factor in the battlefield. An example for all, the rigid control of USA on several technologies considered key for defence equipments (IR, high frequency solid state amplifiers, etc.).

"How the adoption of the dual-use technology, combined with the industrial expertise and high quality military professional skill, can confer to the West a competitive edge".

The real problem is the definitions of the scenarios where the Armed Forces are asked to operate, then the identification of the capabilities necessary to operate and these are pure military tasks. The architectural solution and its operational features can be a task common to military and industrial experts. While the solution definition and its configuration that can adopt dual-use technologies are typical tasks of the Industry.

The right mix of knowledge and expertise can confer to the West a competitive position.

CONCLUSIONS

This Workshop examined the TIC 9.2.2 over one day period. The available time was divided in two parts:

- The first part devoted to presentations of the homework. In fact the participants to the Workshop were asked to propose a Theme related to the selected TIC and relate the position of their company on the subject. A substantiation of the presented principles was very well received because it practically demonstrates the validity of the claimed concepts.
- The second part consisted in a plenary discussion when the group agreed about some statements that can be considered suggestions/actions to be done in order to avoid major problems by the use for military purposes of the dual-use technology.

Although the homework effort and the plenary discussion have an intrinsic value, the results of this session have to be considered as an introduction. In fact each area of analysis requires further in depth study to define a strategy and the relevant rules of behaviour.

What follows are individual summaries of each of the presentations that were made at this Solution Solicitation Session.

Presentation from Pietro Tonini – Finmeccanica on Disruptive Civil or Dual-Use Technologies

- To support the development of the National Intelligence Council's Global Trends 2025, SRI Consulting Business Intelligence (SRIC-BI) was asked to identify six potentially **disruptive civil or dual-use technologies** that could emerge in the coming fifteen years (2025).
  - A disruptive technology is defined as a technology with the potential to causes a noticeable – even if temporary – *degradation or enhancement* in one of the elements of US national power (geopolitical, military, economic, or social cohesion).

1) Biogerontechnology:
   - Offers the means to accomplish control over and improvement in the human condition, and promises improvements in lifespan.
   - The advancement of the science and technology underlying the biological aging process has the potential to not only extend the average natural lifespan, but also to simultaneously postpone many if not all of the costly and disabling conditions that humans experience in later life, thereby creating a longevity dividend that will be economic, social and medical in nature.
   - The disruptive potential comes in the form of new treatment modalities, shifts in the cost, and resulting allocation and use of health care resources.
   - Nations will be challenged as a result of changing demographic structures, new psychologies, activity patterns of aging yet healthy citizens, and the resulting requirement to formulate new national economic and social policies.

2) Energy storage technologies:
   - Have the potential to disrupt the way energy is stored and distributed for use in transportation and portable devices.
   - These technologies include battery materials, ultra-capacitors, and hydrogen storage materials (particularly for fuel cells). Within these components both synergy and competitive tension exists.
   - The biggest level of disruption that could occur, both in economic terms and in terms of global socio-economic structure, would be the potential for one of these technologies (or a combination) to lead to a paradigm shift away from fossil fuels.

3) Biofuels and bio-based chemicals production technologies:
   - Have the only potential near-term capability to provide alternatives to conventional gasoline and diesel-fuel and petrochemical feedstocks.
   - Crop-based biofuels are already in wide use, work in today's vehicles, and require no major investments in infrastructure for their use. Biofuels also help to address global warming concerns by reducing net greenhouse gas emissions from vehicles.
   - The rate of technology advancement will be strongly influenced by the regulatory environment and the need to address feedstock constraints and reduce costs.
   - The United States and a growing number of other countries have already begun a transition toward biofuels that could ultimately have far-reaching impacts on world energy markets.
   - A large-scale move to energy efficient biofuels could increase US energy security and ease international competition for world oil supplies and reserves**.** Conversely, if the United States does not develop a strong bio-based economy the country would become increasingly dependent upon less than friendly countries for a critical energy resource.

4) Clean coal technologies and an array of related technologies:

- Offer the potential to improve electrical generation efficiency, lower emissions of harmful pollutants, and provide fuels and chemical feedstock from available coal resources.
- The development of clean coal technologies is gaining momentum in coal-rich Nations, which include major economic and scientific powers, but it is not certain to succeed.
- Failure to successfully develop clean coal technology in an environment where there is high expectation of success will result in environmental damage with major adverse economic impacts**.** Conversely, a successful accelerated and rapid deployment of clean coal technology could pose a major challenge to other (predominantly oil) energy markets; the resulting geopolitical instability could also be a major challenge to US interests.

5) Robots:

- Have the potential to replace humans in a variety of applications with far-reaching implications.
- Robotics and enabling technologies have already advanced to the stage where single-application robots and related systems (including autonomous vehicles) are being implemented in a wide range of civil and defence applications. Although a great deal of development is still required in terms of *intelligence* for robots, many of the building blocks for potentially disruptive robot systems are either already in place, or will be by 2025, including hardware (e.g., sensors, actuators, and power systems) and software (e.g., robot platforms).
- The use of unmanned systems for terrorist activities could emerge because the availability of commercial civil robot platforms will increase significantly.
- Unmanned military systems with a much greater level of autonomy and closely related/ synergistic technologies (e.g., human augmentation systems) could enhance the performance of soldiers.
- The development and implementation of robots for elder-care applications, and the development of human-augmentation technologies, mean that robots could be working alongside humans in looking after and rehabilitating people. A change in domestic and social responsibilities and a change in domestic employment requirements could adversely affect lower income service-oriented workers.

6) By 2025 Internet nodes may reside in everyday things:

- Food packages, furniture, paper documents, and more. Today’s developments point to future opportunities and risks that will arise when people can remotely control, locate, and monitor even the most mundane devices and articles.
- Popular demand combined with technology advances could drive widespread diffusion of an Internet of Things (IoT) that could, like the present Internet, contribute invaluably to economic development and military capability.
- Streamlining – or revolutionizing – supply chains and logistics could slash costs, increase efficiencies, and reduce dependence on human labour. Ability to fuse sensor data from many distributed objects could deter crime and asymmetric warfare. Ubiquitous positioning technology could locate missing and stolen goods.
- However, to the extent that everyday objects become information security risks, the IoT could distribute those risks far more widely than the Internet has to date.

- Massively parallel sensor fusion may undermine social cohesion if it proves to be fundamentally incompatible with Fourth-Amendment guarantees against unreasonable search.

Presentation from F. Fedi, and S. Cacucci – Space Software Italia on Dual Technologies in Autonomously Cooperating Systems

- The need to protect sensitive areas, both military and civil, key objective in several critical scenarios, such as:
  - Peacekeeping missions.
  - Surveillance.
  - Homeland security.
  - Dual-use missions.

  Needs new paradigms to design distributed, cooperative systems which adaptively cope with external and internal changes.

- An innovative and promising model to manage complexity is the swarm intelligence:
  - Mission – will increase in complexity.
  - People – will be focused to manage mission complexity via ad hoc available resources, both civilian and military.
  - Systems – will be capable to understand the operational context and autonomously act accordingly.

- Context-awareness is considered as a key problem in designing more adaptive applications in dual-use systems:
  - The future dual-use equipment and systems shall be able to understand the specific operational context.
  - Context modelling and reasoning, dealing with high-level abstraction and inference of pervasive contextual information, are key research areas of context-awareness computing.
  - The huge amount of contextual information in dual-use pervasive environment makes existing systems often inefficient, even useless.

- Main areas related to cooperating agents:
  - Biotechnologies:
    - Reverse engineering of biological processes.
    - Molecular computing.
  - Nanotechnologies:
    - Long operation durability machines.
    - Huge integration scale.
    - Smart materials and surfaces.
  - Robotics (hard artificial intelligence):
    - Emulation of human/animal reasoning.
    - Integration of biological and artificial intelligence.

- Dual-use pervasive reasoning:
  - Each agent correctly identifies the context (military/civil) where it is operating. It processes information accordingly.
  - Physical agents autonomously cooperate to support human operators in accomplishing dual-use (civil/military) complex missions.
  - The environment will host a population of context-aware appliances such as cameras, person identification and tracking devices, each acting as an autonomous device which is also able to ad hoc cooperation on perception of authorized human needs.
  - The set of appliances will act as a pervasive reasoning system which will deliver the right information, to the right person, at the right place, at the right time, to make the right decision.
- Key software technologies – 2030:
  - Information assurance mechanisms for micro/nano platforms:
    - Molecular computing.
    - Quantum computing.
  - Real-time middleware for micro/nano platforms:
    - Molecular computing.
    - Quantum computing.
  - Biological inspired reasoning:
    - Swarm intelligence.
    - Brain reasoning.
    - Ontologies.
- Current SSI R&D:
  - Swarm intelligence.
  - Real-time middleware for pervasive computing.
  - Information assurance mechanisms for pervasive computing.
  - Ontologies/reasoners.
  - Multi-agent integration platforms.

Presentation from D. Brizzi – ThalesAlenia – Space on Space-Based Systems Dual-Use Opportunities and Challenges

- GMES “Global Monitoring for Environment and Security”:
  - An EU led initiative, in which ESA will implement the space component … and the Commission will manage actions for identifying and developing services.
- The objective of GMES is to provide, on a sustained basis, reliable and timely services related to environmental and security issues in support of public policy makers’ needs:
  - S1 (SAR Imaging) – all weather day/night monitoring and surveillance applications.
  - S2 (Multi-Spectral Imaging) – for land applications, forestry, agriculture, etc.
  - S3 (Ocean and Land Monitoring) – wide-swath ocean colour, vegetation, sea and land temperature, ocean altimetry.

- S4 (Geostationary Atmospheric) – atmospheric composition monitoring, trans-boundary pollution.
- S5 (Low-Orbit Atmospheric) – atmospheric composition monitoring.

- Applications are sometime complementary, especially in the domain of “security” (see after), where there are a lot of complementarities, also induced by the strict cooperation between civilian/ military governmental institutions on “crisis management”:
  - Quite ambitious programs, requiring heavy investments on new technologies.
  - Heritage/lesson-learned on “dual-use” confirm benefits on reducing costs, minimizing risks.
  - TELECOM:
    - Capacity of military satellites is widely complemented by commercial satellites (about 80% of capacity in USA).
    - Many examples of Military satellites used to support civilian operations to manage emergency conditions (e.g., SICRAL, SYRACUSE).
    - ATHENA-FIDUS – specifically conceived for dual use.
  - EARTH OBSERVATION:
    - Implicit/explicit reuse of technologies (not specifically labelled):
      - USA:
        - Commercial high resolution satellites use/re-use many of technologies developed for military satellites.
        - DoD strongly relies on “commercial services” (e.g., CLEARVIEW, NEXTVIEW).
      - EUROPE:
        - Strong commonalities on SPOT (civilian) and HELIOS (military) programs.
        - COSMO-SKYMED is the first example of EO system specifically conceived for dual use.
  - NAVIGATION:
    - GPS/GLONASS – originally developed for military utilization, they are now widely used for civilian applications.
    - GALILEO – going to adopt specific solutions for dual use.
  - There is no specific differentiation on technologies; the difference is mainly on the way they are used to develop specific solutions/applications.
  - ITAR (International Traffic in Army Regulations) are the main constraint/driver to be taken into account.

- EU strategic interest on the theme of “SECURITY”:
  - Protection against terrorism and crime:
    - Technology solutions for threat awareness (e.g., CBRN).
    - Detection, prevention, identification, protection, neutralisation and containment of effects of terrorism and crime.
  - Security of infrastructures and utilities:
    - Analyzing and securing existing and future infrastructures, systems and services.
  - Border security:

        - Technologies and capabilities to enhance security of land and coastal boarders, including border control and surveillance issues.
    - Restoring security in case of crisis:
        - Technologies to support emergency management operations, inter-organisational coordination and communication, distributed architectures and human factors.

- Meanwhile space is widely recognized a critical enabler for security and defence:
    - NATO currently does not have a space policy or space strategy.
    - There are military, civil and various national space capabilities available to NATO.
    - NATO has a need for, but is lacking space situational awareness, space control (assuring and defending the domain) and needs to better integrate national space capabilities in order to be able to conduct combined space operations.
    - A NATO space operations coordination centre may also need to be established.

- Strengths:
    - NATO countries have a predominant positioning from a technological point of view.
    - USA and European countries (e.g., under EC/EDA/ESA sponsorships) are already pushing forward.

- Weaknesses:
    - Lack of a coordinated NATO space policy:
        - Lack of coordination, fragmentation of funding.
        - Space assets vulnerability.
        - Lack of “integration”, leading to possible failures in collaboration, tasking, analysis, etc.

- Opportunities:
    - Dual-use synergies, interoperability with civilian systems.
    - Possibility to pool existing and/or planned national/regional capabilities (e.g., at European level).

- Threats:
    - Increasing capabilities of potential opponents:
        - Conflicts/divergences on strategic interests.
        - Delays on planning and implementation.

- Recommendations:
    - Expand and deepen US/EU-NATO strategic dialogue, progressively involving other Partners, with the objective to set new policies oriented to:
        - Develop compatible visions of requirements, roles and responsibilities.
        - Cooperate on research and procurement.
        - Pool resources to field multi-national capabilities/units, share infrastructure, focusing attention on interoperability.
        - Identify specialized capabilities to be developed at national level, taking into account local capabilities/expertise.

Presentation from Francesco Rogo – Finmeccanica Defence Product Policy on Dual-Use Technologies: Convergence in Military Communications

- Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services, and military as well.

- Network-Centric Warfare – the underlying principles are:
  - The network improves the sharing of information.
  - Information sharing and collaboration enhance the quality of information and awareness of the current situation.
  - Awareness of the current situation improves collaboration and self-synchronization, hence speed of command and action.
  - As a result, it increases greatly the effectiveness of the mission, because it allows you to take better decisions in less time ... to understand and act before the others.

- The foundation of the doctrine is information superiority:
  - In the same way…The deep changes in the socio-economic context, due to the proliferation of digital networks and Information (IT) and telecommunication technology, but also in the number of markets and their increasing liberalization are changing the foundations of society: education; health; transport; tourism; mobility; business; ways of conceiving the relationships; and social groups.

- Network-Centric Operations:
  - Network-Centric Warfare (NCW) evolves towards the Network-Centric Operation (NCO) concept for the management of homeland security systems and crisis management, but in the future this convergence will be more and more strict with the commercial and social environments.
  - Main issues related to networking in the future NCO areas include the security of transmissions, the robustness of the transmission, the transmission capacity, the routing of messages and signals (especially the new wireless networks).

- Internet of the Future:
  - The new boundaries that are opening up with the Internet usage in the medical, educational, public administration, social life in general (mass wireless connectivity, IPv6, etc.) lead the definition of the paradigm of the ‘internet of the future “(still being defined in international fora).
  - The Web 2.0 will have at the center the “contents”, information, and interactions among users (active players, e.g., Blogs, wikis, social network, podcasting, Vodcast, virtualization) by integrating the technologies of the semantic Web with the pervasive computing, ambient intelligence, with applications and service-oriented components (Web Services, Agent Technology, Application Service Gateway), dynamic composition, orchestration and discovery of new services (applications context-aware reasoning and ontology).
  - All these new applications/services and disciplines converge in developing convergent network architectures (i.e., enabling discovery and access to services and applications without distinction of the channel, protocols and the type of media) and in the development of middleware and network protocols that facilitate implementation of such services and content.

- Ambient Intelligence:
  - Ambient intelligence is the paradigm that uses traditional media to which people are accustomed (home) enhanced by an embedded technology, but not intrusive (computer disappearing) that can perceive through multi-modal sensors not only the state of the environment but also of the user and its needs. A distributed intelligence with self-learning processes to optimize the operation of the service needs.
    - For example, in Home Care bidirectional connection of domestic and multi-modal channels with the outside world (Internet/broadband), complemented by specific wearable devices (biometric) will remotely monitor the status of the subject by a specialized centre.
  - It is predicted that a massive flow of information based on wired and wireless networks (GSM, UMTS, WiFi, Bluetooth, etc.) will be needed to control local automation and use of web-based technologies for the remote management and integration with services outside.
- Pervasive Computing:
  - Pervasive computing is the next major evolutionary step in information technology, merging the notions of networks and computers with everyday devices. Devices like vehicles, household, appliances, and cell phones are already equipped with embedded microcontrollers. The networking of the myriads of embedded devices gives rise to a new world of pervasive computing.
  - Embedded systems have become a centrally important aspect in a wide variety of applications, ranging from hand-held devices to household appliances up to RFID tagging of goods, in field such as automotive, info-mobility, railroad safety, location-based services, smart cards, e-voting and e-wallet functions.
  - Critical features of evolution in pervasive computing shall be the capability of software updates remotely and current inappropriate and inadequate interaction models (user interfaces and sensors).
  - One aspect of this evolution is the rise of new security issues. Security will be an enabling technology for new business model (fee-based feature and location activation of embedded systems functionalities).
- UAV and Homeland Security:
  - Applications in homeland security will receive a major boost from the use of mobile systems for the monitoring of the area including aerial platforms and surface – possibly of type unmanned (UAV and UGV, respectively) equipped with appropriate sensors and can transmit their information remotely through networks and wireless connections air-air, air-ground and satellite like MANET and IP-Oriented.
  - To date, military aircraft are not yet fully considered as a network node (other than the LINK16 LINK 11/22 networks and that are highly segregated), whereas on civilian aircraft are already present and will be even more integrated onboard services for:
    - ATC/ATM.
    - Passenger commodity.
  - The corresponding dual military case will be:
    - Civilian space flight (especially UAS).
    - Mission.
  - In this field civil technologies (e.g., router), will provide the starting point, to be adapted to specific needs (e.g., safety flight in the case of UAS, currently outside the core business of CISCO).

- Even in the communication field (e.g., satellite links) "dual use" applications will grow. The military unmanned platforms must be provided with all systems of communication (and identification/surveillance) provided for civil functions like ATC/ATM.

- Software Defined Radio (SDR):
  - The SDR platform which provides the hardware Radio-Frequency (RF) resources, the Input/ Output (I/O), the security features and the programmable computing resources (FPGA, DSP, etc.) able to support a specified set of software applications. The platform is designed to establish radio communication links within a specified range of frequency bands and data rates.
  - The waveform applications (Modes, Waveforms or Air Interfaces) which execute in the SDR platform and configure it in front of dedicated radio-communication standards, allowing the SDR equipment to be part of the related radio communication system.
  - The SDR will be the "dual-use" technology par excellence in the communications field.
  - The Software Communications Architecture (SCA) will under pin SDR and is an open architecture framework that tells designers how elements of hardware and software are to operate in harmony within a software defined radio. SCA is based on the platform-waveform paradigm, i.e., the capability to load different waveforms on a radio platform waveform layer. It will offer:
    - Robust and adaptive protocol stack, multi-level, with the ability to cross-layering.
    - Burst vs. constant traffic.
    - Reactive vs. proactive routing.
    - Adaptive data rates with sufficient granularity.
    - Enlargement of spectral capabilities covering various RF bands.
    - Instantaneous adaptive bandwidth.
    - Coexistence of CDMA/TDMA techniques.
    - Using OFDMA in a meshed QoS.

- Cognitive Networks:
  - Cognitive radio is a paradigm for wireless communication in which either a network or a wireless node changes its transmission or reception parameters to communicate efficiently avoiding interference with licensed or unlicensed users. This alteration of parameters is based on the active monitoring of several factors in the external and internal radio environment, such as radio frequency spectrum, user behaviour and network state.
    - Spectrum Sensing – Detecting the unused spectrum and sharing it without harmful interference with other users.
    - Spectrum Management – Capturing the best available spectrum to meet user communication requirements. Cognitive radios should decide on the best spectrum band to meet the quality of service requirements over all available spectrum bands.
    - Spectrum Mobility is defined as the process when a cognitive radio user exchanges its frequency of operation.
    - Spectrum Sharing – Providing the fair spectrum scheduling method, one of the major challenges in open spectrum usage is the spectrum sharing. It can be regarded to be similar to generic media access control problems in existing systems.
  - Main gap is:
    - Artificial intelligence for distributed cognitive processing.

- Other gaps:
  - General purpose digital technology (computational speed and power):
    - A/D, GPP, DSP, FPGA.
  - General purpose radio frequency technology:
    - Multi-band coverage.
    - Tx/Rx chain dynamic range (amplitude, bandwidth), linearity.
    - High stability multi-band frequency synthesis.

- Spectrum Issues Arising from Dual-Use Technologies Availability:
  - HF-band is used in the Air environment as the primary BLOS communication means to aircraft, land and maritime mobile platforms. Information is exchanged via HF radio in voice, message, and data link formats. HF is also used for air traffic control purposes when beyond the range of VHF facilities. Problems pertaining to the use of the HF-band cannot be solved in isolation by regulations and the availability of dual-use technologies (new modulation and adaptive control techniques) could make worse the situation.
  - The main issues to be addressed:
    - Realignment and reallocation of the 7 MHz range.
    - Searching and identifying possible additional spectrum for HF BC between 4 and 10 MHz.
    - Classification of power line technology.
  - As part of tactical broadband aviation in Line Of Sight (LOS), the only band currently allocated in the international context is the Ku (NATO J-band) but for civilian uses is the chaos (the data links on small UAVs sometimes operate in L-band around GHz, other times in S-band just above the 2 GHz, no uniformity of regulation).
  - Within the aeronautical tactics satellite communications situation is evolving situation according to the availability of satellites and their coverage – today in frequent the using of INMARSAT (in L-band) for civil applications and, sometimes, military, and for data rates up to a few hundred of kbps.
  - For higher rate usually using the Ku-band (11 – 14 GHz) commercial satellite communications, the same as for television broadcasters, and even here there are both civil and military applications. In the military field there are satellites in X-band (8 GHz) and V (43 GHz). For UAVs this appears to outweigh the choice of C-band (around 5 GHz) for LOS and SAT connections, in line of principle, both for military and civilians.

- Security – IP and Crypto software Module:
  - Security – A key requirement for developing the concept of NCO is the availability of a network infrastructure and information robust, safe and effective able to provide information to anyone (authorized), everywhere and at all times.
  - All over IP – The communication component of a NCO network will more and more based on the Internet Protocol (IP) to provide a common mechanism of transport for different types of data and information, in transit to various types of communication links. On the other hand, there is a clear trend in areas of commercial, military and government usage of converged network infrastructure, is based on IP, capable of delivering the three main types of traffic: voice; data; and video. This trend will increase dramatically with the introduction of the Ipv6.
  - The high availability of IP addresses and the capabilities of mobile and embedded security in the new version of IP will enable applications and services unimaginable, encouraging the development of network-centric concept.

- The introduction in the SDR of the crypto engines will make it interoperable also with regard to classified communications (typically military). There are also interesting implications for mobile phones – in fact the "crypto engine" installed on the SDR will be able to automatically change the encryption algorithm and the level of relative security level, according to the type of user or device that wants establish a communication.

- Security – Trusted Computing and Elliptic Curve Cryptography (ECC):
  - As for the IT terminal (computer, PDA, mobile phone) and their inherent security weakness, the platform standard Trusted Computing (TC), where the term "trusted" means the expectation that a device behaves in a certain way to for a specific purpose, promises to bridge this gap. The main objective is to make the devices intrinsically safe by the joint use of hardware and software.
  - In particular, each device equipped with a TPM (Trusted Platform Module) chip with a pair of cryptographic keys that cannot be modified, which allows to implement mechanisms of asymmetric cryptography, applied for the following purposes:
    - Unique identification of the device.
    - Encryption performed in hardware in a secure manner.
    - Information signed with the key of the machine.
    - Information encrypted with the key of the machine.
  - Elliptic curve cryptography is an approach to public-key cryptography based on the algebraic structure of elliptic curves over finite fields. ECC has recently been endorsed by the US government. Standardized by NIST, ANSI, IEEE, IETF.
  - The size of the elliptic curve determines the difficulty of the problem. It is believed that a smaller group can be used to obtain the same level of security as RSA-based systems. ECC performance better due to smaller keys and smaller communication overhead in handshaking.

- Summary remarks:
  - One issue is how to guarantee security of information and security of supply.
    - Main issue is how to manage the obsolesce of COTS components.
  - Furthermore, there is quite some craftsmanship needed to combine the right dual-use technologies with a few remaining defence specific technologies for efficient and effective (large scale) military applications.
    - Mainly in security items and algorithms.

Presentation from Daniele Cecchi – Elsag Datmat on Dual-Use Technologies in C2 Systems

- Technologies that are very popular in the civilian domain are becoming popular in C2 systems too, namely:
  - Internet technology (networking, grid/cloud computing).
  - Web portal technology (integration of applications).
  - GIS, 3D visualisation tools (scenario representation).
  - Modelling and simulation tools (e.g., serious gaming).
  - Logistic information systems.

- For all these technologies the leadership is clearly in the civilian domain:
  - Market share.

- R&D investments.

- The benefits that the application of dual-use technologies in C2 systems can bring are really important:
  - Dual-use technology provides an opportunity to import high quality innovation at reasonable costs – for business processes, products and services.
  - This is where the West through the combination of its economic strength, industrial base and high quality military professional skill still has a competitive edge.

- This is expected to have a positive impact, mainly in terms of:
  - Cost and deployment time – use of COTS products.
  - Functionality – new and enhanced.
  - Interoperability.
  - Performance.
  - Workload, reaction times – more automation.
  - User acceptance.
  - Standardisation.

- The risks associated with the application of dual-use technologies and products include:
  - Adaptation to military requirements – How advancement in civil domains can be spin-in effectively in the military domain:
    - Prototyping vs. development.
    - Security of information can reduce significantly the performance and functionality of products.
    - Priority given to "de-facto" rather than "de-jure" standards.
    - Integration with defence specific technologies still required for efficient and effective (large scale) military applications.
  - Lack of knowledge and control:
    - Possible presence of virus in proprietary SW products.
    - Limited possibility of customisation.
    - Rapid evolution.
    - Security of supply, lack of stability, difficult to have long-term commitment for maintenance.
    - Openness of the technology – very difficult to maintain technological dominance (predominance of civilian technology).

Franco Cavagnoro Elsag Datamat on Cloud Computing

- Cloud computing is a style of computing where scalable and elastic information technology enabled capabilities are delivered as a service to external customers using Internet technology. It has the following characteristics:
  - Service-Based – Consumers and providers of the service are abstracted through well-defined service interfaces that hide implementation details. The service is off-the-shelf, designed to serve a specific need, and technologies are tailored to the need, rather than vice versa.
  - Scalable and Elastic – The service automatically scales capacity up or down on demand.

- Shared – Services share a pool of resources that are used with maximum efficiency.
- Uses Internet Technologies – The service is delivered using internet protocols, web oriented architecture and service oriented architecture.
- Exclusive Membership – Only approved users can access the services. The network can be implemented on a public infrastructure with restrictions, or on a totally segregated infrastructure.

- Current state of use includes:
  - Cloud computing, also known as utility computing – APS (Application Service Provisioning), SaaS (Software As A Service). The concept and the need have been there since the late '90s.
  - Cloud computing is beyond the hype stage and in the early commercial adoption stage.
  - There are many US dedicated commercial providers – Boomi, Cast Iron Systems, Informatica, Pervasive Software the best known names.
  - Suppliers of services on the Internet have moved to the cloud delivery concept (salesforce.com, Amazon.com, Google) or are considering it (ADP, FedEx).

- Possible dual uses of cloud computing:
  - Segregated Internet-based infrastructure.
  - Scalable and elastic infrastructure.
  - Shared pool of resources to deliver the services.
  - Services available on the infrastructure to authorized users.
  - Services and users interface through well-defined infrastructures.
  - Technology adapts to the needs of the services and the users.

- Examples of dual uses of cloud computing:
  - Data, signal and video streams available on a channel-subscriber model.
  - Massive background storage for field applications, for non time-critical information or past performance and status information.
  - Massive data bases – data warehouses.
  - Mission planning services.
  - Logistic support services.
  - Ground support services.
  - Debriefing services.
  - Training services.

- Strengths:
  - Technology fits the needs of the service.
  - Any service at the nearest "plug".
  - As much power as needed, when needed and where needed.

- Weaknesses:
  - Multi-level security needs to work seamlessly.

    - What happens on a sunny day (no cloud available)?

- Opportunities:
    - By 2015 widespread commercial adoption provides learning on the pros and cons of the approach.

- Threats:
    - By 2012 the cloud fizzles commercially, again.

Presentation from ELT Electronica on Dual-Use Technologies in the EW Domain

- The shrinking of military budgets produced fewer newly acquired equipment, featuring both reduced development NRE and production RE. These conditions have practically cancelled from the market most military technologies and military grade (MIL grade) components (Hi Rel), which were available on the market for a long period.
- To-day military equipment uses a large number of civilian (or commercial) technologies and components. This trend will be further increased on next generation equipment.
- Military equipment is usually acquired for a quite long operational life (15 to 20 years). Commercial components/technologies are subject to an extremely rapid evolution with an equally limited life on the market. Thus military equipment inevitably suffer from component obsolescence.
- This presentation deals with the current and next future use of civilian (COTS) technology in the military EW domain, showing that what is currently perceived as an opportunity at the initial acquisition can become an issue during the operational life of a novel military equipment.
- COTS:
    - Information Technology – Operating system (VxWorks); Microprocessor (Power PC / Pentium); Programming language (C/C++).
    - High sampling rate ADCs for wideband multi-carrier application and direct IF conversion.
    - Fast DSP/FPGA for high speed application (fast demodulation and decoding for latest digital links – OFDM, CDMA, etc.).
    - MMI – PC/Windows-based.
    - µw GaN power amplifiers.
    - DDS synthesisers.

- Obsolescence issue:
    - The unavailability of some obsolete component within a board or module of an equipment implies that the latter cannot be repaired in case of failure.
    - This issue is usually solved according to two alternatives:
        - Last Time Buy (LTB) of obsolete components.
        - FFF (Form Fit Function) Re-design of the board/module comprising the obsolete component.
    - The first solution is usually applied in the case of a limited series production as the cost of the buy and stock is still convenient.
    - The second solution is instead applied in the case of series production prolonged in time (usually large number of equipment).
    - In the following the methodology used by Elettronica for the second solution is briefly reported.

- Re-design for obsolescence removal:
  - The large Praetorian (EFA DASS) (> 700 equipment along 12 years) with the maintenance requirement of >25 years from the delivery is a good example of this solution.
  - Current forecast about the next 4 years indicates 400 to 600 obsolete components over the complete equipment.
  - To cope with this issue ELT introduced the obsolescence process in the production area (see next slides).
  - Indeed for the last series production batch the situation at ELT is:
    - Up to 18 SRI (many of them with multiplicity) of the 30 SRI constituting the ELT Equipment have to be redesigned for obsolete components (i.e., 60%):
      - 7 SRI are video digital boards.
      - 4 SRI are power supplies.
      - 6 SRI are RF modules.
      - 1 SRI is a processor board.
- ELT Obsolescence Process 1:
  - The ELT obsolescence process is chaired by obsolescence office managing all the components and devices through the equipment Bill of Material (BOM).
  - The BOM is managed by configuration system (PDM Matrix) and ERP SAP.
  - The obsolescence office receives input from suppliers, consultant companies, ELT experience and automatically updates the information through Matrix and SAP for the current obsolescence. A monthly database is generated to take into account obsolescence having “end of life” within 2 years and 4 years.
  - The obsolescence office informs production, procurement, technical and programme team to manage the obsolescence and any impact for resolution, redesign or LTB according to production, technical and programme requirements.

Presentation from A. Auletta – Finmeccanica on Dual-Use Technologies

- The growth continues thanks to the innovation and progress of the processing and communication technologies that allow to conceive systems always with more multi-function capabilities with features of scalability, modularity and service oriented.

- The last frontier of the electronics applied to defence are the “system-of-systems” which integrate all the Armed Forces assets, making them potentially interoperable for coalition operations with those of other Armed Forces.

- Some examples of dual-use technology:
  - The communications sector:
    - The communication sector is a meaningful example of dual-use basic technologies always more developed in the civilian sphere and applied to military and institutional markets, often adopting the same equipments.
    - This is mainly a consequence of the higher investment capability of the players operating in the civilian market.
    - From the technology point of view, the evolution of the telecommunication products and systems is pulled along by the following factors:

    - The growing fusion of the IT component with that of pure communication.
    - Convergence of communications (voice, data, video), interoperability of the networks, security and quality of the service.
  - Command and control systems:
    - Strong requirements of modular, scalable, interoperable, possibly low cost (COTS) and "fit-to-purpose" applications.
    - Always less distinction between military and civilian with a potential risks of new comers coming from the commercial electronics.
    - Greater growth of opportunities driven by the IP and software-like technologies.

Presentation from Carlo Falessi – SELEX Sistemi Integrati on System-of-Systems and Open Society Technologies

- A System-of-Systems (SoS) is a "super-system" inclusive of elements that are themselves complex, independent systems which interact to achieve a common goal. Main features include:
  - Real time.
  - Multi-user.
  - Multi-domain.
  - Multi-platform.
  - Net-centric.
  - Inter-operable.
  - Safety and security.
  - SOA.
  - SIM/TRAIN/ORG.
- For a SoS, the Customer does not require nor is able to specify the products requirements. The Customer is able to specify the operational performance:
  - Always more often the Customer asks for a "service".
  - Always more often the cautious Customer asks for "evolutionary services".
  - Always more the "services" are global and complex (i.e., Airport Security, G8 Security).
  - For global and complex systems, SoS are needed that inevitably aim at being "Integrated SW Dependent Large Systems".
  - SoS are the new frontier.

Technology Focus Areas

- Resilience engineering.
- Self-regulating or evolving organisations or societies.
- Improving capability acquisition strategies and processes.
- Rapid change in the commercial world vice reluctant change in the military world, change process analysis.

H.13.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Building resilience training into our education system.

Technology Focus Areas

- Gaming as a whole – multi-agent systems, biometrics, group dynamics.
- Knowledge management (not just information gathering or IT piece of managing knowledge).

H.14 CAPABLE OF ENABLING AN EFFICIENT SUPPORT CHAIN FROM HOME BASE TO POINT OF USE IN AN OPERATION WITHIN AN INTEGRATED MULTI-NATIONAL LOGISTIC ENVIRONMENT

H.14.1 Theme-Issue-Capability Description

TIC 10.1.3 – Non-Military/Non-Violent Threats

The Alliance will face a variety of hybrid threats in the future. These include non-military threats where the source of the threat are non-conventional military forces and non-violent threats wherein, though it may be an enabler or an intended consequence of the action, violence is not an inherent element. These threats could come about through deliberate action, accidental occurrences or natural disasters. The cause and effect of these events is not limited by borders and are characterized by difficulty in prediction, detecting, localizing and typically involve little or no warning. They require trans-national coordination and inter-agency cooperation to resolve. Examples of these types of threats include:

- Computer network attack;
- Pandemics;
- Mass migration; and
- Natural disasters.

Issue – Expansion of the Mission Set

Shifting responsibilities in the different phases of the whole security chain allow for an expansion of the potential roles of Armed Forces throughout this security chain: from analysis and early warning; through general prevention and preparation; specific prevention and preparation; protection; pre-emption; response; to recover; and evaluate.

How may the core competences of the military – such as unity of command, unity of effort and disciplined and enduring action under stressful circumstances – be best applied and expanded in the comprehensive security domain?

Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment.

H.14.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.14.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Commercial world leading the way on logistics.
- Best practices now likely to be best practices in future as well:
  - Unique stock numbers.
  - Total asset visibility.
  - Configuration control.

  - Common standards (and common interpretation of those standards).
- Reduced footprint reduces overall logistic needs.
- While logistics in 21 years may well be very different, we have nothing more than wild guesses now on what it would look like that isn't closely related to what we already observe today.
- The only part of this TIC not likely to be covered elsewhere is how to better manage logistics chains that require multi-national collaboration and those that travel through dangerous areas. TIC 4.2.13 above addresses the first Issue.

Technology Focus Areas

- None identified.

Solutions

- None identified.

H.15 CAPABLE OF RESEARCHING AND EXECUTING STRATEGIES THAT MITIGATE THE NEED FOR LARGE NUMBERS OF FORCES

H.15.1 Theme-Issue-Capability Description

TIC 11.1.1 – Regeneration

Most NATO Nations have moved away from large forces toward smaller, more professional and more technologically intense forces as the threat from a peer competitor has receded over the last decades. The focus has moved to fighting short, intense battles against a medium sized force or conducting, what had been termed 'lesser included', missions such as counter-insurgency or stabilization/reconstruction. Regeneration refers to the ability of the Alliance to restore operational capabilities that formerly had been in its inventory or to develop a capability that is technically feasible but is not available for immediate use. Regeneration includes recognizing the need for taking action, conceptualizing the capabilities, deriving DOTMLPFI and producing the capability.

Issue – Quantitative Regeneration

Ability to timely regenerate a down scaled capability "in numbers", and to employ those numbers in a coordinated, probably echeloned way. A crucial element might be agreements with dual-use industry to rapidly tailor civil "look-alike" products and production lines to military applications.

Capable of researching and executing strategies that mitigate the need for large numbers of forces.

H.15.2 JO 2030 Phase IV Out Reach Results

S16 – DRDC Office of the Chief Scientist Session 2

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Lots of tech trends point to more tech solutions and less human-centric solutions:
  - By optimizing techniques (both capacity and capability through OR).
  - Capacity enhancement – better operational awareness and folding robots and the human into the overall system can better reduce per human/soldier footprint and better recruitment and retention.
  - Capability enhancement – Delisting mil specifications to enhance use of off-the-shelf equipment.
- Improved and multi-disciplinary training can lead to working with smaller force numbers.
- Human to human conflict resolution:
  - What is the efficacy of hearts and minds campaigns' in the context of non-human-centric solutions?
  - If we are morally unable to 'pave it' and rebuild, how do we 'win' the war?
- Human performance enhancement – super humans:
  - Through biochemical or biomechanical enhancements or prosthetic devices.
  - Build emotional resiliency into military ethos.
- Threshold between man and machine will lower with an increase in effectiveness.

- Reducing the rotational cycle (doing more with what one has) – speeding up reintegration and retraining. Lessen the impact of deployment– improved and embedded training vs. immersive training, i.e., down loading knowledge.
- Poses a societal challenge – military-civilian separation vs. integration:
  - Change the educational paradigm – everyone participates in the military in lieu of education – develop intellectual capital.

Notes from Study Leader:

- A societal challenge – military-civilian separation vs. integration?
  - Differing national focus and commitment.
- Improving or enhancing use of ISR technologies.

Technology Focus Areas

- Biochemical and bio-mechanical enhancement and augmentation of the warfighter.

H.15.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Sometimes, large forces are necessary – the Russians had a 10:1 force ratio in Chechnya, stabilisation ops (Afghanistan) requires presence and security over a wide geographical area, a small Nation needs numbers if confronted with a larger, conventional opponent.

Technology Focus Areas

- One strategy is smart robotics – use autonomous robots in support functions and/or warfighting roles.
- One reason numbers are dwindling is that each platform/soldier become more capable, hence more expensive. The drive for increasing capabilities is that we want to make sure our soldiers win – and survive. We therefore need the best weapon systems, the best armour, the best electronic support measures, etc. We could break this cost-capability spiral if we substitute many inexpensive, single-role, unmanned systems for the big, multi-role, expensive manned systems. Those we can afford to lose ("suicide-systems" for conventional warfare).
- Improved autonomous monitoring of borders, HVAs, wide-area coverage, etc. Need research into sensors and detection algorithms.
- Need more research into the collaboration between man and machine. People, robots and reach-back will all be elements in future ops. How to optimise the way these operate together and communicate.
- Utilize existing (but untried / not legally cleared) technologies that enhance defensive capabilities, i.e., various non-lethal weapons:
  - Sonic.
  - Laser dazzler.
  - Electro-magnetic weapons (EMP, HPM, etc.).

Solutions

- Multi-national cooperation (investments, exercises, maintenance) may be imperative – specialisation among Nations allow the upholding of larger combined forces:
  - Trading the risk of having too few forces against the risk of depending on foreign governments (NATO, other multi-lateral, bilateral).

H.16 CAPABLE OF FORWARD OPERATIONAL PLANNING FOR COMPLEX ENDEAVOURS ACROSS THE DIFFERENT STAGES AND IN A MULTI-AGENCY ENVIRONMENT

H.16.1 Theme-Issue-Capability Description

TIC 12.1.5 – Three Domains of War: Physical, Mental and Moral

Kinetic activity associated with traditional military operations has been joined by actions in the moral and mental (information) domains as equal components of a success campaign plan. The war of ideas, hearts and minds, fourth generation, amongst the people has stressed the relevance of the moral and mental domains. As asymmetric adversaries avoid exposing themselves to the superior conventional force of the Alliance, the importance of actions outside the physical domain become more obvious. Within irregular warfare the importance of the moral domain becomes dominant as the security of the people becomes an overarching goal. In the future, physical actions will be used to enable the achievement of objectives in the mental and moral domains.

Issue – Need to Develop Capabilities that Act in the Information and Moral Domain

The character of war is expanding from just traditional force-on-force engagements to more asymmetric engagements/endeavours where the focus is on the mental and moral domains. The need to ‘win the peace’ must be incorporated into the force structure / capability development process as well as in the operational planning process and operations. As an example, it might become of prime importance for NATO to craft the message that is transmitted across multiple media to the numerous audiences that could impact operations. This will include friendly, adversary and neutral audiences. Also, effects in the physical domain may be instrumental to achieving effects in the information and the moral domain.

Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment.

H.16.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.16.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Development of the concept of trust in the domain of operational planning.
- Allowing operational planning to be spontaneous (emergent).

Technology Focus Areas

- Methods/tools to identify trust (on an intercultural dimension) and incorporate it into operational planning.

Solutions

- None identified.

H.17 CAPABLE OF ACTING WITHOUT ACCESS TO CYBERSPACE

H.17.1 Theme-Issue-Capability Description

TIC 12.2.6 – Three Domains of War: Physical, Mental and Moral

Kinetic activity associated with traditional military operations has been joined by actions in the moral and mental (information) domains as equal components of a success campaign plan. The war of ideas, hearts and minds, fourth generation, amongst the people has stressed the relevance of the moral and mental domains. As asymmetric adversaries avoid exposing themselves to the superior conventional force of the Alliance, the importance of actions outside the physical domain become more obvious. Within irregular warfare the importance of the moral domain becomes dominant as the security of the people becomes an overarching goal. In the future, physical actions will be used to enable the achievement of objectives in the mental and moral domains.

Issue – Cyber Security

To what extent is cyber security a military issue (as opposed to a more general societal problem)? When does the information domain become a (virtual) battleground? What are doctrine and ROEs for cyberspace?

Capable of acting without access to cyberspace.

H.17.2 JO 2030 Phase IV Out Reach Results

S18 – DRDC Ottawa

Notes from Study Leader:

- What is cyberspace? Is it almost any network? Is the power grid part of cyberspace?
- It is a complex system and need to build it for effectiveness vs. efficiency.
- The more complex a system, the more that is built into it and the more likely that when it fails it will fail catastrophically.
- How do the principles of a complex system apply to this problem?

Technology Focus Areas

- Complexity science and cyberspace security studies.

H.17.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Long-term denial of cyberspace would render NATO forces impotent.
- Emphasis probably better spent on ensuring access through robustness, redundancy, protection.
- For short-term loss of cyberspace, mainly a training issue:
  - Empowerment at low levels.
  - “Archaic” fallback methods (paper maps, supply forms, manual navigation aids).

- This is not to say that there aren't relevant technologies within the C3 and information systems domain that shouldn't be furthered to ensure cyberspace remains protected and robust. However, the participants were not knowledgeable about these topics, and one suspects they are already under investigation by other entities.

Technology Focus Areas

- None identified.

Solutions

- None identified.

H.18 CAPABLE OF ACTING WITHOUT ACCESS TO SPACE ASSETS

H.18.1 Theme-Issue-Capability Description

TIC 14.1.2 – Space is Opening Up

By 2030 the amount of traffic in space will have increased markedly requiring coordination and regulation. The Alliance will remain dominant in this area with capabilities for ISR, navigation and weather observation based in space. The commercial sector of particularly Western economies also relies heavily on space communications. The reliance of the Alliance on space could develop into a Focus Area for possible adversaries that could seek to exploit this potential 'Achilles Heel'. Space junk and anti-satellite systems are threats to the usage of space during operations. Commercial enterprises have built to allow even small groups to have access to space imagery that could be used for intelligence purposes. Space Situational Awareness becomes an important component for future Alliance operations.

Issue – Critical Dependence upon Space Assets

The dependence on space assets for, e.g., communications, surveillance, navigation causes increased vulnerabilities and risks to NATO's capabilities, both in an economic sense as military.

Capable of acting without access to space assets.

H.18.2 JO 2030 Phase IV Out Reach Results

S1 – Washington

From ACT Notes:

- Space deny could be averted by developing new, cheaper, faster launch options such as micro-satellites, sling-a-trons, space planes, systems parked in far orbit in cold storage that would make the task of denying space prohibitive for adversaries.
- Could also be done with redundant systems within space vehicles or redundant space vehicles as well as increasing protection/hardening of space vehicles.
- Training will be a vital component of denial to space. Other navigation, communications, targeting systems must be retained to cope with the possibility of complete loss of GPS.
- There are many legal issues associated with space:
  - Weaponization.
  - Property rights and exclusive access to the moon.
  - Nuclear-powered space craft.
  - Commercial activities in space.
- May require the development of space systems that could rendezvous with and investigate spacecraft in orbit to determine their purpose or destroy/deny.
- Use of kinetic rods delivered from space may have the same effect as more powerful weapons while allowing the capability to be disguised from friendly sensors. Could use hard to detect, low signature materials and commercial launch capabilities to further hide the capability. This could lead to the requirement to monitor/regulate payloads and develop a better space

situational awareness capability that would allow monitoring of the increased material in space brought about by the increased, cheaper launch options.

- Larger commercial activities in space may come with a concomitant expectation of government abilities to conduct rescue operations.
- There are differing perspectives on exploitation of space. The West seeks to exploit space for research while China and India look to space as a commercial opportunity to harness power/ commodities.

Require the ability to attribute a DEW attack on a space system to a particular site on the earth.

S11 – Brussels

Notes from LCO Christian Micha:

- How would you describe a possible solution or solution approach for the capability in the context of the Issue in the 2030 time frame?
  - Restore space assets fast.
  - Locally develop backup applications:
    - UAVs for ISR.
    - Use of mobile phone antennas for positioning or combined use of GPS and Galileo working at a multiple frequency ranges and hybrid systems that are capable of using other types of signals.
  - SATCOM – Setup satellites with a broader perspective; i.e., not only focusing on national interests, but also leaving some capabilities for other Nations. SATCOM satellites indeed tend to become more and more complex, with more and more onboard and inter-satellite processing. This trend has advantages for the satellite owner, but it constitutes a big obstacle to interoperability. NATO or EU constellations consisting of quasi transparent (i.e., repeater-type) satellites, technically accessible to all members, along with solid fall-back agreements between the owning Nations could be a step forward.
  - Standardization – Reconsider the balance between commercial and global interests.
- Is there a roadmap to your solution (things already in the “pipeline”, enablers, drivers, required technologies, critical points)?
  - Standardization is a key issue.
  - Political will for interoperability.
  - Increase in space R&D investments within EU.
- Are you aware of institutions/people already working on solutions to this capability requirement?
  - European institutes.
  - MUSIS – An attempt to standardization of the ground segment for all European military remote sensing satellites.

S14 – Rome

Report from Mr. Ennio Giaccari, ITA:

Facilitator: Guido Bottale

- The discussion was firstly dedicated to a common understanding on how the spatial assets might be lost. The satellites are several hundreds and in the 2030 it is reasonable to foresee that they will be many more.

- Notwithstanding that it is possible to expect that a single satellite or terrestrial terminal station in small geographical area might be disturbed by jammers or directly threatened by a new generation of weapon systems, it seems unreasonable that all satellite functionalities (used by a military force of a Nation or a coalition) may suddenly disappear.
- Then, during the discussion, it was agreed what services might be only interrupted or degraded (meaning for instance that one or more satellites providing a service become unavailable).
- In these conditions the group proposed alternative solutions to recover the necessary services.

What is your understanding of the capability?

- The satellite-dependent services are *positioning, navigation, observation* and *communications*.
- It was agreed that *positioning* and *navigation* are the most vulnerable services because they are nowadays mainly based on space assets (e.g., GPS/Galileo) and also a partial or temporary unavailability would considerably influence the operational capabilities of the joint operation forces.
- In the field of the ***observation*** service the working group stated that satellites could be backed up by means of a set of sensors installed on airborne platforms (e.g., UAV, balloons) for short to medium distances detectability and by ground-based Over The Horizon (OTH) radar systems for long-range surveillance.
- ***Communications*** may be replaced mainly through other SATCOM (the preferable solution) or ground-based assets such as Beyond Line Of Sight (BLOS) radios systems, cognitive radios and existing fibre optic infrastructures.
- During the final discussion of the Workshop, other solutions came up, mainly aimed at hardening the survivability capabilities of a “space-based service”:
  - **Prevention Measures** – They consist in measures capable to protect the ground and space assets. Among these it is worth mentioning the Electronic Counter Counter Measures (ECCM) systems to counteract/deceive threats and active weapons (e.g., lasers/missiles).
  - **Reconfiguration Measures –** It must be possible to use different satellite constellations and to swap from one to another in real time in accordance with the availability of the service or health status of the equipments. This would require the capability of ground assets to be interoperable. Another possibility could be, in case of lack of one or more satellite within the same constellation, the repositioning of the remaining ones so that the service is maintained.
  - **Increase of Intrinsic Availability** – The assets are made survivable through redundancy techniques applicable either to space or to ground. In particular, the ground assets of a satellite-based service are the most vulnerable to a threat and therefore it should be important to have some backup stations to ensure that the simple impairment of a hub station, unique for all the system, could cause the complete stop of the service.

How would you describe a possible solution or solution approach for the capability in the context of the Issue in the 2030 time frame?

- Based on the above considerations the requested capability in *positioning and navigation* could be recovered by a mix of well-established solutions (e.g., inertial navigation with the introduction of new technologies such as M-NEMS – Micro-Nano Electro Mechanical Systems) that shouldn’t be abandoned and the introduction of new ones (e.g., radio-based positioning functionalities).
- Satellite-based o*bservation* might be backed up by means of a set of capabilities based on a combination of airborne platforms (e.g., UAV, balloons) and ground-based OTH radar systems.
- *Communications* may benefit of a wide set of solutions using a combination of:
  - Radios exploiting the radio propagation characteristics of the Troposphere and Ionosphere (in HF, VHF and UHF bands as troposcatter, HF sky wave, meteor bursts systems).

    - Cognitive radio technology exploiting any possible and reachable radio system through interoperability negotiation and adaptive usage of the local spectrum conditions.
    - Sky repeaters (UAV, balloons) in order to extend the radio coverage especially in areas without ground communication infrastructure.
- For example, assuming that a SATCOM service, used by a NATO force in Afghanistan both as connection to homeland and for local communications, disappears (either the hub stations or the satellites). The most reasonable solution is to swap immediately to another SATCOM service made available by another ally to guarantee the continuity of services (reach back and local communications). This may only be possible with an adequate deployed radio configuration (antennas, radio transceiver, etc.) and with an agreement with the service supplier.
- In order to save bandwidth of the backup SATCOM a military unit might exploit the BLOS connectivity for its local needs reserving the SATCOM for the connection to the homeland. The switch to other communication services implies that the systems are all interoperable, which is an essential capability for the joint forces.
- In conclusion, it is not possible to envisage a complete back up solution but rather a set of solutions, partly already established and partly completely new that shall be modulated according to the operational scenarios and following an accurate analysis of costs-benefits.
- Rating of pertinent technologies is provided in the following table.

Table H-2: Table of Technologies that Address the Loss of Space Assets.

Critical Capability	Envisaged Solution	Technology Area	Constituent Technology			
			Promising but immature	Under development	Leverage commercial development	Mature in industry
Joint Operation in absence of space assets	Space assets Survivability: Prevention	Electronic protection and weapon systems		Anti missiles systems		ECCM systems
	Reconfiguration	Automatic selection of the asset			Adaptive networking Software Radio Technology	Redundancy of Ground Hub Stations
	Availability	Redundancy				Satellites redundancy
	Positioning and navigation w/t satellite	Navigation based on Inertial Systems Radio based Positioning	Inertial systems based on N-MEMS	Inertial systems based on MEMS of new generation		Traditional Inertial systems
	Observation w/t satellite	OTH Radars Air based observation	Ionosphere refractive prediction models		Air floating platforms, balloons, UAV...	
	Communications w/t satellite	BLOS comms Cognitive Radios	Distributed cognitive processing		UAV, balloons as repeater platforms ... Mobile Ad Hoc NETworking (MANET) Software Defined Radio technology	HF sky wave Troposcatter radios

Is there a roadmap to your solution?

- For most of the indicated solutions a case by case cost benefit analysis should occur in order to choose the most appropriate one.
- Among the new technologies it is worth to mention:
  - OTH radar for observation does not have any known roadmap.
  - Cognitive radio technology is on the way, driven by commercial and military market and has a shared roadmap compatible with the year 2030.

  - Gyroscopes that can assure position accuracy compatible with hours of mission. These equipments might adopt new emerging technologies among which MEMS of future generation such as M-NEMS.

How would you assess the likelihood of a gap in the 2030 time frame?

- This answer was understood by the group simply as how far are we from a solution?
- It is clear that for most of the solutions we are not far, or better we have already the solution and therefore the problem is simply to take a decision.
- For OTH radars the distance might be relevant since it requires basic research.
- For communications, the cognitive radios (the most innovative among the mentioned technologies) will be available on time.

How would you assess the impact of the capability gap on NATO operations in the 2030 time frame?

- For all the satellite dependent services the impact may reach dramatic levels up to the complete loss of essential functionalities if none of the recommended solutions is taken.

Are you aware of institutions which are tackling this Issue?

- The unique known institutions are on the cognitive radio issue:
  - DARPA.
  - IEEE SCC 41 (Dynamic Spectrum Access).
  - SDR Forum.

S17 – Kingston

Notes from Study Leader:

- Cable of acting but with much limited effect and much longer timelines.
- Counter with reversion and redundancy.
- Adaptability is not on the A List?
- Space weather.
- Reconstituting the ‘network’ at a functional level should not be.

Notes from Dr. Gitanjali Adlakha-Hutcheon:

- Smart Dust Smart Pollen – ad hoc mobile connectivity using near space orbit – stratosphere-based.
- Environmental and legal implications when we start using smart dust.
- Networked balloons, networked air assets; not such a big of a deal for communications, as it relies on time signal of GPS and can be reconstituted by atomic clocks quite quickly.
- Counter with reversion and redundancy.
- Adaptability is not on the A List? (Because everyone is working on this).
- UN agreement on the commons of space.
- A space-based system less vulnerable than ground-based GPS; time sync.

S18 – DRDC Ottawa

Notes from Study Leader:

- Alternative positioning, communications, imaging.
- Moments of opportunity, i.e., an adversary waits for the next big solar to launch the attack.
- Need to watch and protect the vulnerability of land-based support systems.
- Should there be a study of the vulnerabilities?
- In general have NATO's critical infrastructure issues been defined?

Technology Focus Areas

- Micro-satellites, alternative space vehicles.
- Redundancy measures.
- Drone-based navigation and communication systems.
- Smart dust and pollen to build ad hoc connectivity.
- Networked balloons and air assets.
- Protection of ground-based assets.
- Inertial systems based on N-MEMS.
- Distributed cognitive systems.
- Ionosphere refraction index prediction.

Solutions

- Cognitive radio technology exploiting any possible and reachable radio system through interoperability negotiation and adaptive usage of the local spectrum conditions.

H.18.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Functions:
  - Surveillance.
  - Navigation.
  - Weather forecast.
  - Communications.

Technology Focus Areas

- Swarm of autonomous, networked UAVs. With advanced sensors and image/map processing these could provide navigation aid, surveillance and comms. Each of them could be small and/or specialised and hence be relatively cheap. Research areas (theoretical research, simulator trials, small-scale tests ongoing, but system is not fielded, mainly because FAA and society are not ready):
  - Peer-to-peer collision avoidance.
  - Image processing algorithms.
  - Collaborative/networked, but autonomous operations.

- Enabling technologies – enhanced batteries (high capacity, long endurable, rechargeable).

Solutions

- Back-up/reserve satellites, ready to be launched at short notice. This would be a solution, but it would be expensive and not instantaneous.
- Maintain legacy systems for nav/com (LORAN), etc. Many of these are being (have been) closed down, but could be an alternative if required:
  - Problem – Users are not trained to use legacy systems.
  - Possible solution – Fuse the different, make systems adaptable, graceful degradation.
- Commercial aircraft equipped with sensors. Need to be regulated through treaties (as satellite imagery).
- Using ships/aircraft as base stations for communications.
- Aerostats, long-endurance UAVs (years+), C-130s.
- Automated star positioning techniques (mature) – incorporate in existing systems.

H.19 CAPABLE OF ESTABLISHING HOW MILITARY ACTIVITIES CONTRIBUTE TO ACHIEVING POLITICAL OBJECTIVES AND END-STATES, AND VICE VERSA

H.19.1 Theme-Issue-Capability Description

TIC 16.1.7 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future ‘mission space’ is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the ‘whole-of-government’ or ‘comprehensive’ approach; and
- The need to garner public support for ongoing operations.

Issue – Achieving Campaign Level Surprise

Because of its current political decision process, including red-card holders and national caveats, NATO-led endeavours can hardly achieve campaign level surprise. In general military operational tempo is often not matched by political-military decision-making.

Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa.

H.19.2 JO 2030 Phase IV Out Reach Results

S21 – DRDC CORA Strategic Analysts

Notes from Study Leader:

- Complexity is decision-making in a strategic situation and is a given.
- The system is not a problem – it exists to make it work.
- What is the purpose of the Alliance? – Is it a balance point between sovereignty – commitment – national interests?
- Failure here is not because of the ‘process’ but because of the non-alignment of policy and objectives across the political dimension.
- Where will the EDA and NATO go – will the EDA take on the whole role?
- There is a lack of unified commands.
- This should be based upon threats.
- How do you create a NATO strategic culture from 26 very different national strategic cultures?

- Many of the processes that are in place are there to deliberately limit and contain the strategic-military connection.
- Comprehensive approach = more players = lower overall response.

S24 – DRDC Toronto

Notes from Study Leader:

- Can military force achieve political end-states?
- Is or should the goal be to raise a state to a Huntington 'Level of Stability'?
- Changing the way that people see the world, to work at expanding perceptions of different cultures – "The we is the us that is not them".
- Research into methods and applications of facilitating inter group/agency working and relationship building.
- There is no grand strategy to NATO apart from maintaining the status quo.
- 'Political objectives' are rarely defined beyond the broadest of principles.

Technology Focus Areas

- Process and policy studies particularly across changing and shifting political dimensions.
- Conflict management studies – alignment or misalignment of various national interests with a pan NATO interest.

H.19.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- This TIC was not reviewed during the MNE.

Technology Focus Areas

- None identified.

Solutions

- None identified.

H.20 CAPABLE OF CONDUCTING CIVIL-MILITARY COOPERATION IN AN INTER-AGENCY ENVIRONMENT

H.20.1 Theme-Issue-Capability Description

TIC 16.3.1 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the 'whole-of-government' or 'comprehensive' approach; and
- The need to garner public support for ongoing operations.

Issue – Comprehensive Approach

- Embedding military capability/efforts in inter-agency endeavours.

Capable of conducting civil-military cooperation in an inter-agency environment.

H.20.2 JO 2030 Phase IV Out Reach Results

S10 – Czech Republic

Notes from CZE Rep – LtCol. Ivo Pikner:

- A cooperation between IOs, NGOs, military and other agencies and entities acting in future operations is NOT about the technology, but rather about the good (political) will and endurance, and about DRIVERS OR ENABLERS.
- A capability to sensitively cooperate between military components and the inflicted population.
- A capability to function in advanced stage at the evaluation/assessment of information about the upcoming conflict.
- An implementation of new international principles (coalition's strategy, EBAO, etc.).
- A readiness of multiple/modular components for joint activity (preparation of human resources, experts, funds, legislation, SOPs, etc.).

Report from Brno, Czech Republic S3:

Introduction

On 28 January 2009, the JO 2030 Solution Workshop was conducted at the University of Defence of Brno in the Czech Republic. The Workshop was conducted in the Czech language as national contribution for the support of LTSS JO 2030 and led by the DDPS[1] Branch Head of ISDS UD[2], LtCol. Ivo Pikner, Ph.D. This was the first Czech national Solution Solicitation Session; the only one topic of Solution Solicitation Sessions focused to problems of political transformation was being dealt with in the Seminar.

Aim of the Seminar was to outline the role and effect of "political transformations" for future NATO Joint Operations within the time horizon 2025 – 2030. The Seminar attendees presented, based on their theoretical knowledge and practical experiences their attitudes on what a role of political transformation will play in influencing the outcomes of operations. Recommendations were presented at the conclusion of discussion, on what capabilities the NATO should dispose so that the expanding of distorted information is prevented as such information influence the public opinion unfavourably thus the result of operation.

Workshop Approach and Organization

- First CZE Workshop used a knowledge and approach from previous Solution Solicitation Sessions (Oslo).
- Topic S3 focused to one field (political transformation) was selected in advance (8 TICs).
- Particular organizations and experts dealing with mentioned topics were addressed (approximately one month) in advance.
- Basic information on LTSS JO 2030 and JO 2030 were part of invitation pack (A-list TICs were not included).
- In respect to the expected number of attendees the session was not divided into break-out sessions and it was run in one group.
- A moderated discussion was held in the first part to create the atmosphere in which the future operations are to be conducted; discussion in the second part was focused to answer the pre-set questions.
- S3 was recorded by note-takers.
- Participants focused to CIMIC **TiCV: 16 – 3 – 1 – 141008** after the opening discussions.

Outputs from Discussion – CIMIC

- Creation the most effective model of cooperation between the military and civil part of operation aimed to achieve the complex solution of a given conflict – EBAO.
- Creation the capability to cooperate between the military component and the inflicted population in the given country.
- Readiness of multiple components of the MOD MOG for joint activity in abroad (preparation of human resources, funds, legislation, etc.).
- Creation of teams capable support the cooperation between civilian and military structures on a given territory – SOP (Standard Operation Procedures).
- CIMIC has influence to future operations – it can function in advanced stage at the evaluation/ assessment of information about the upcoming conflict.
- Way of solution of capabilities, e.g., formation of CIMIC units, based on the active reserves (these would be trained together with the regular army units).
- Accepting of joint standards and joint preparation of experts of all Departments involved.

[1] The Department of Defence Planning Studies.

[2] Institute for Strategic and Defence Studies of the University of Defence.

- Complex multi-lateral missions with various types of actors (army, civilian components, reconstruction team – PRT, etc.) will be conducted in the future; these will be planned in one prior the operation seeking to get a wide spectrum of local communities involved.
- Future military conflicts will be influenced by the CIMIC, first of all in the field of mediation of civilian assistance from the NGOs + involvement of governments and other organizations of the "host country" – support of the "host country" (impacted at the level of governments of countries involved in the particular conflict so that the restoration of economy and peace and stability are achieved in the respective country.

Conclusion of Attendees

- The CIMIC is NOT about the technology, but rather about the good will and endurance, it is NOT about technology in the narrow sense, but rather about DRIVERS OR ENABLERS.
- The 3-generation peace missions (concept) – partial implementation of new principles in the field of EBAO shows the possibilities of the CIMIC.
- The future CIMIC is, first of all about cooperation of MFA, NGOs, military and other entities acting in the future operation environment.

Notice: The CIMIC works and it is well pre-set principally; mistakes and shortcomings (if any) are rather to appear during the 3rd phase, i.e., during the period when the governmental bodies are getting involved in the process of support of the impacted country.

S21 – DRDC CORA Strategic Analysts

Notes from Study Leader:

- Grand Strategy – 3 Ds (defence, diplomacy, development) comprehensive approach, whole of Government.
- CIMIC is an enabler of the comprehensive approach.
- CIMIC is a tool in the tool box.
- Comprehensive approach lies in the middle of the spectrum of conflict.
- How can non-kinetic effects fit into the comprehensive approach?
- In using a system-of-systems approach agreement of the desired end-state is essential.
- In the absence of a serious threat the comprehensive approach has not had a lot of success.
- Agreement on end-state, means, methods and goals is very hard to achieve.
- Provincial reconstruction teams?
- Getting NATO internally to act comprehensively is hard – achieving this externally is even harder.
- Can or will a systems-based approach provide a means to an end – assuming the end-state can be defined and agreed to?

S22 – DRDC Suffield

Notes from Study Leader:

- It is a two way challenge.
- Embed military capabilities in civilian products and processes and vice versa.
- Mixed message – Global Hawk with or without Hellfire?

S24 – DRDC Toronto

Notes from Study Leader:

- Organizational Culture: CIMIC is military-centric, US vision is to support the Commander, Euro vision is to enable the society – JIMP is cooperative and participative.
- Alliance Formation: Understanding their goals and constraints – so that you don't misunderstand – how do these groups connect, communicate, cooperate – technology can assist but training, selection, and personality characteristics are important.
- Cross cultural psychologies.
- Perceptions of who you are.
- Optics – how do you deal with them?
- Mentoring and trust versus master and servant.
- Social organisations need to be able to function.
- Many studies focus on differences and ignore commonalities.

Technology Focus Areas

- Cross cultural psychology studies.
- Relationship and network building – mentoring and trust versus master and servant.
- Learning and info sharing.
- Relationship building based on growing commonalities and less on managing differences.

H.20.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Clear need to communicate with all, or as many as possible, of the other organizations/bodies. Leads to the need for a common communication mechanism (cell phone, radio, etc.) coupled with the need to be able to understand the words, meanings and motives of the other parties. Auto language translation is already available (e.g., Wordnet, SpeechGear) but the incorporation of gestures, body language, eye movement, skin temperature would provide additional accuracy (and indications of veracity?). Desirably to be achieved by a "soldier wearable box", but if this is not possible then provide training in how to interpret such gestures would be valuable.
- Will also be necessary to develop and share cultural awareness/sensitivity to the objectives, goals, aspirations of the various organizations together with individuals within those organizations.
- Necessary to build trust between both between individuals and between organisations. This is complicated by the aspect of rotation in and out of theatre – leads to how to carry over trust and how to build up trust rapidly. Social networking techniques (Facebook, MySpace, Twitter, etc.) could be investigated as means to speed up trust building.
- Need to incorporate the methods of working with other organizations into our training. Such training to be as rapid and efficient as possible.
- Potential need to add/modify our current organizational structures to reflect the requirements to efficiently collaborate with these external bodies. Could involve expertise from anthropologists, economists, sociologists, etc.
- Need to gather and maintain a large amount of information on potential partners/agencies prior to entering theatre.

- Need to have a continuous situational awareness of all agencies within theatre. Noting that some (many?) agencies will not wish to be seen cooperating with the military or with other agencies. Could lead to the need for a more complex version of multi-level security and the developments of commonly accessible portals for information sharing.

Technology Focus Areas

- Auto language translation incorporating other sensors such as gestures, body language, eye movement, etc.
- Auto speech to text transcription (for subsequent storage).
- Contextual analysis and intent recognition tools.
- Social studies designed to identify and develop cultural awareness (e.g., social modelling/ networking, anthropology).
- Social studies related to how organizations and individuals can efficiently interact when they have competing goals and objectives.
- Social studies related to rapidly building trust between organizations and individuals with disparate goals, cultures and objectives.
- Research to identify human characteristics that build trust.
- Training – rapid and efficient methods:
  - Develop better cognitive understanding of learning.
  - Develop/adapt multi-player gaming to our needs (existing RTO study on application of gaming in the military?).
  - Develop training in how to interact (involving knowledge/sensitivity training about disparate cultural norms).
- Research into complexity theory – may lead to the development of efficient ways of working together.
- Organizational theory.
- Research into alternative/efficient “management” constructs and structures (potentially involving concepts such as “focus and convergence” vice traditional C2).
- Research on the efficient development, maintenance and interrogation of large knowledge bases.
- Inter-agency COP potentially supported by “Green Force Tracker”, “OnStar” or GPS / cell phone exploitation such as “Google Tracking”.

Solutions

- None identified.

H.21 CAPABLE OF FORMULATING AND EXECUTING SHARED AND REALISTIC ACTIONS

H.21.1 Theme-Issue-Capability Description

TIC 16.3.3 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the 'whole-of-government' or 'comprehensive' approach; and
- The need to garner public support for ongoing operations.

Issue – Comprehensive Approach

Embedding military capability/efforts in inter-agency endeavours.

Capable of formulating and executing shared and realistic actions.

H.21.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.21.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- This TIC was not reviewed during the MNE.

Technology Focus Areas

- None identified.

Solutions

- None identified.

H.22 CAPABLE OF COLLECTING IN A TIMELY MANNER THE IMAGERY, DATA, INFORMATION AND INTELLIGENCE ON OPPONENTS AND THE ENVIRONMENT REQUIRED TO MEET ALLIANCE END-USER REQUIREMENTS

H.22.1 Theme-Issue-Capability Description

TIC 16.3.4 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future 'mission space' is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the 'whole-of-government' or 'comprehensive' approach; and
- The need to garner public support for ongoing operations.

Issue – Comprehensive Approach

Embedding military capability/efforts in inter-agency endeavours.

Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements.

H.22.2 JO 2030 Phase IV Out Reach Results

S14 – Rome

Report from Mr. Ennio Giaccari, ITA

Facilitator: Peter Collins

The technology theme of this break-out session deals with the timely collection of imagery, data information and intelligence on opponents and the environment required to meet Alliance objectives, whilst the political theme is the political transformation. The first observation of the group was that they could not see correlation between the political and technology themes. Besides, it was felt that political transformation was not an issue for industry. For this reason, the group chose to focus on the capability for data gathering and classification referred to technological issues.

These aspects are shown in the presentations relevant to the TIC. In particular the presentations emphasize:

- The space as an unrivalled source of information.
- The visualisation platforms as an essential resource to facilitate the data analysis by humans.
- A new approach for data collecting which is based on finding the truly critical in critical infrastructures, coordinating networks of sensors and other distributed "agents", building the teams that will implement it all.

- That, while it is envisaged a continuous progress in engineering, physics, mathematics, it is hard to see breakthroughs in human sciences that are vital for knowledge layer and for handling deep uncertainty.

What is your understanding of the capability?

The group felt that, leading up to the 2030 time frame, the real discriminator in the future will be the human dimension. Nevertheless engineering and technology issues are not by any means solved, steady progress will continue, and besides this progress will be dominated by the commercial sector the defence sector will take care of defence specificities as needed.

This means that the cognitive aspects, which were to some extent covered in the presentations, have to be integrated with other aspects such as the methodology of data gathering, the connection to a reference model to interpret the acquired data, the training of personnel on the application of uniform criteria of interpretation and classification.

These criteria, based on a selected set of principles and application of creative algorithms, should aim at achieving a transparent, uniform, selective database easy to access for further processing.

How would you describe a possible solution or solution approach for the capability in the context of the Issue in the 2030 time frame?

Given the focus on the human dimension, in its broadest sense, the approach needs to be based on the so-called “soft sciences”. In addition it was strongly felt that a new mathematical language or approach will be required. There has been very little conceptual progress in this domain in the last 25 years.

Rating of pertinent technologies is provided in the following table.

Table H-3: Table of Technologies that Advance the Collection of Imagery, Data and Information.

Critical Capability	Envisaged Solution	Technology Area	Constituent Technology			
			Promising but immature	Under development	Leverage commercial development	Mature in industry
Collection of imagery, data information and intelligence on opponents and the environment:	Conjugate cognitive aspect based on data acquisition from up-to-date families of sensors with the creation of a transparent, uniform, selective database easy to access for further processing.	Soft sciences, new mathematical language, specialised algorithms Man/machine interface Psycho-pathology Psycho-sociology	Inference engine for non-conventional logic Domain ontologies Decision aids	Agent based architecture Open Service-Oriented Systems Single website for search and situational awareness	Middleware Human language technologies Dual-Use synergies, inter_ operability with civilian systems	Data processing Data fusion Embedded systems

Is there a roadmap to your solution?

The answer was felt to be “yes and no”. No in terms of defining when conceptual breakthroughs will occur – it is clearly not possible to put a time frame to these. Yes in the sense of defining the enabling

mechanisms required in order to develop an increasing understanding of the issues.
In particular there are clear roadmaps as far as the technological evolution of physical sensors and the relevant capabilities that can be achieved. In general this technological evolution is strongly dependent on the investments in the commercial sector.

A dedicated effort needs to be applied in the field of "soft sciences" in order to define interpretation and classification rules matched to the relevant social, economical and cultural environment.

This can be achieved in the future with guaranteed continuity of investments.

How would you assess the likelihood of a gap in the 2030 time frame?

This depends on whether the governments have the political will at NATO level to make the necessary investment commitments over an extended time frame. These investments should be addressed to the adaptation of future commercial "soft sciences" solutions to military requirements such as the real-time availability of specific military needs.

How would you assess the impact of the capability gap on NATO operations in the 2030 time frame?

As stated above, hardware and technology will advance steadily and data gathering will be always more pervasive. More and more, therefore, the human dimension needs to be explored in order to interpret the acquired data. Classification, archiving and information retrieval will be critical, and absence of a solution will deprive NATO of a discriminator over its adversaries, whether asymmetric or Nation-based.

Are you aware of institutions which are tackling this Issue?

This question was felt by the group to be best left to the government representatives of the study to answer.

In summary, the fundamental plea of the break-out group was for the governments/NATO to show the political will and give the political and funding commitment to the necessary work in this domain.

S18 – DRDC Ottawa

Notes from Study Leader:

- Cognitive radios and spectrum exploitation – bandwidth limitations and ROI questions.
- Bandwidth is constrained by the laws of physics therefore need to work the information end – stop sending all the data – imbed information in context – use network management strategies.
- Data compression techniques.
- One strategy is collect all data centrally fuse and analyze it or alternatively to apply a lot of local and layered processing and analysis.
- Bandwidth is a limitation – make better use of current bandwidth – network management – local analysis, information compression – the strategic level is well served with lots of optical cable and satellite networks – but at the tactical level this is much more constrained.
- Watch for commercialisation of imagery collection assts.
- Blue Force – who is in the coalition and what do they need? White Force – what are they doing?
- Who exercises spectrum control of the jammers?
- How to answer the question of what information needs to be sent from what platform, i.e., the problem with the Canadian Coyote reconnaissance vehicle having the best informed Corporal.
- Push the data processing to the lower level to reduce the need for bandwidth.

S24 – DRDC Toronto

Notes from Study Leader:

- Extract 'meaning' from text.
- Data analysis.
- How can we understand or 'mind read' an adversary?
- EGG blast – FMRI.
- Better understand human cognition and augmented cognition.
- How do you measure and what do you measure – what are the state stability indicators – can one get past the 'correlation is not causality' problem?
- Mind reading: FMRI / polygraphs / physiological monitoring / facial change monitoring – none are work 100% of the time.

Technology Focus Areas

- Cognitive radios and spectrum exploitation.
- Bandwidth constraints and data compression.
- Network management strategies.
- Data-information-knowledge chain analysis in a distributed network – information needs vs. information generation vs. information location.
- Studies on FMRI / polygraphs / physiological monitoring / facial change monitoring.
- Soft science including psychopathology and psycho sociology.
- Man machine interface.

Solutions

- Conjugate cognitive aspects based on data acquisition from up-to-date families of sensors with the creation of a transparent, uniform, selective database easy to access for further processing.

H.22.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Processes need refinement so that in selecting priority data for transmission, important information is not filtered out. The resulting distribution process could free-up bandwidth because only important information would be provided to decision-makers. Onboard processing of information and transmission of only relevant information will reduce bandwidth.
- Need to determine the relationship between pieces of information in order to track data and related information gathered over time in the same area.
- There was the observation that some of these processes are not sequential as in the past, but continuous. In the future, more continuous/real-time analysis of information is required rather than sequential, whereby information is first collected and then analysed. A more dynamic, integrated and concurrent process is needed.
- Does the quality of the information need to be adaptive to the circumstances?

- Information sufficiency is a needed concept – when do you have sufficient information for your needs? Related to reducing bandwidth by gathering only the necessary intelligence.
- Prioritizing what we collect so as to reduce the amount of data that goes unanalyzed.
- Pervasive sensors will require tools that do, at least, rough analysis to reduce the amount of information for manual analysis.
- Target recognition will be more automated in the future.
- More disposable, cheap, swarming sensors, including UAVs, are needed. These swarms will provide more data than large, low density assets such as Global Hawk.
- Energy systems for sensors will be important as the energy demand is related to the sophistication of the sensor.
- There are potential advantages to investigating the use of commercial sources of information (i.e., social networking sites) as a complement to military specific sources.

Technology Focus Areas

- Bandwidth.
- Computational science.
- Artificial intelligence.
- Metadata management and labelling.
- Tactics, techniques and procedures.
- Tool development.
- Energy science and engineering.

Solutions

- None identified.

H.23 CAPABLE OF UNDERTAKING IN-DEPTH FORESIGHT ANALYSIS TO DEVELOP MODELS OF THE FUTURE SECURITY ENVIRONMENT

H.23.1 Theme-Issue-Capability Description

TIC 16.3.8 – Political Transformation

Political transformation may be needed if the Alliance is to achieve a fundamental military transformation. The future ‘mission space’ is expected to require quicker and more decisive action at all levels of command. The capability to achieve strategic surprise calls for political acceleration and dominance. Projection of trends into the future shows that individual Nations will exhibit support for those issues that truly matter to all but sometimes ambivalence to those about which they have reservations. This manifests itself as political agreement to an operation, but failure to then take a fair share of the burden. Political transformation will require:

- The capability to arrive at political decisions in a timely manner;
- The need to share equitably the burden of risk and cost;
- The incorporation of the ‘whole-of-government’ or ‘comprehensive’ approach; and
- The need to garner public support for ongoing operations.

Issue – Comprehensive Approach

Embedding military capability/efforts in inter-agency endeavours.

Capable of undertaking in-depth foresight analysis to develop models of the future security environment.

H.23.2 JO 2030 Phase IV Out Reach Results

S21 – DRDC CORA Strategic Analysts

Notes from Study Leader:

- From the future security environment Symposium – this can’t be done.
- The Alliance provides:
  1) Collective defence.
  2) Primary forum for discussing security affairs concerning the trans-Atlantic Alliance.
  3) International peace and security issues – can these strategic concepts be sorted out?
- Supporters of NATO miss the main problems of NATO, namely institutional inertia – and yet NATO retains ongoing and continuing advantages in spite of its dysfunctionality.
- Foresight analysis – Europe uses it but uncertain of the results, North America dubious of its use.

Technology Focus Areas

- Organizational alignment and structure analysis.

H.23.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Need the integration of human, social, cultural, behavioural modelling to predict future security environments to include the involvement of anthropologists, economists, sociologists, historians, etc.
- The need to integrate numerous modelling fields and accurately apply risk assessment leads to the need for improved algorithms, high speed processing and enhanced computational techniques.
- The need to integrate numerous modelling fields leads to the need for extracting information from large amounts of data. This will include developing advance data gathering techniques, storage and retrieval techniques, and data validation.

Technology Focus Areas

- Organizational theory.
- Complexity theory.
- Stochastic estimation.
- Agent-based modelling.
- Quantum computing.
- Alternatives to silicone-based computing devices.
- Risk assessment models.
- Data and information management technology covering very diverse sources.
- Data mining.

Solutions

- None identified.

H.24 CAPABLE OF DESIGNING EFFECTIVE MEDIA STRATEGIES

H.24.1 Theme-Issue-Capability Description

TIC 17.1.3 – The Role of Information and the Media

The media has become instrumental in developing the context for the public audiences that affect the Alliance. The pervasive 24/7 media cycle will continue to create the 'CNN effect' where strong emotional content can engender public reaction which may affect political and military decision-making at all levels of command. There is a symbiotic relationship between the military and the media in that the media requires access and information and the military needs the media to communicate with the public. The increased instantaneous access to information available to the public will be a serious consideration in the future as public perception can drive constraints on both the political and military levels.

Issue – 24-Hour Media Cycle

The Alliance will work in an environment where the news media will be pervasive and will have access to (near) real-time transmission capabilities to a global audience. This could harm military operations. Or is this something that the military can try to influence or take advantage of? The speed with which media can report on incidents during operations far exceeds ability of Commanders to present a comprehensive insight into the NATO 'side of the story'. This can most certainly result in incorrect, possibly volatile information being spread through a theatre of operations bring about serious consequences.

Capable of designing effective media strategies.

H.24.2 JO 2030 Phase IV Out Reach Results

S10 – Czech Rep

Notes from CZE Rep – LtCol. Ivo Pikner and Petr Tichy:

- Media will continue to be a significant factor of the success of the operation.
- Media will keep their own independence – they will cooperate with the military as with other resources.
- The quality and speed of information has been primarily influenced by the development of technology, however, further development of technology will not be the crucial factor.
- Prevailing trend is the continuous acceleration of information – incorrect – require corrections and a need to create own capability in providing information, e.g., by establishing own TV channel).
- Development of internet – anybody can be a journalist today, internet will lead to a far bigger visualization, however, sound (audio) will stay far more important than visualisation.
- Basic way of influencing the public opinion is to assure the provision of information through trained members of the Armed Forces (to train all members, even at tactical level, on what kind of information the soldiers can provide to the media and what is restricted).
- Media are a source of information for the enemy, media of the adversary will always influence operations – INFOOPS, PSYOPS – growing role of disinformation.

- Trends for future:
  - It is foreseeable that the media will keep their own independence even in a long-term horizon. They will cooperate with the military as with one from the resources of information.
  - It cannot be expected that further development of technology will be the crucial factor in the field of media. Means of mass communication might be a bit smaller by dimensions or a bit faster but fundamental change is improbable.
  - Far bigger stress will be put to the speed of providing the information. Media will, without any doubt, become a source of information for the enemy.
  - Development of internet and up-to-date technologies lead even nowadays to “amateurization” of media (practically, everybody can be a journalist today).
  - Development of internet servers will lead to further pressure on the speed of providing the information. Internet will lead to far bigger visualization of information.
  - Making our own capabilities for Alliance seems to be as very probably for the future, especially with respecting the big competition that exists even these days actually.
  - System of preparation and pertinent training of the members of military and PR seems to be rather more effective.
  - Role of media in operations around 2030 will not be less significant; it will rather grow up on the contrary. It is possible to assess that possible reduction of significance of “traditional media” to come and consequent increase of other means of media linked to internet and to new forms of distribution or processing the information.
- The “War of Media” in all fields of human activities is going on currently.
- Military will have to cooperate and be helpful to the newspapermen in providing information, both during post-conflict period as well as in the course of conflict. Military will have to perform actively when providing information to public via media, but also via own PSYOPS.
- Newspapermen are and will stay, as well as the soldiers will, under pressure of 24/7 time frame (acting non-stop).
- The needs of possibility of transmission of information from anywhere and at any time with the top quality are being dealt nowadays already, and technologies are available as well (access to k internet and/or satellite communication). Possibility of broadcasting and transmission of information from anywhere in the world are solved already.
- One workstation for transmission of information from anywhere for a single-member team is currently easily available.
- Sound (audio) will stay far more important than picture (visualisation).
- Pressure to information update will be far more emphasized in the future than the quality.
- Need of solve technologically (both SW and HW) the capability of analyzing information from increasing number of resources and information themselves (information boom, congestion) is rising for the future. Selection of some resources (reliable – indexing of resources).
- Official linkage – interconnection of information resources with users – official information automatically.
- Role of law and legal loyalty of the people versus newspaper praxis versus loyalty of media will grow up.
- Communication technology determining technological possibilities are not a problem now – the problem is a human being.

- Media of the adversary side will always influence the environment of operation. As a result of this, future capability of separate the information for “backyard” and for operation comes out (INFOOPS, PSYOPS).
- Complex environment of EBAO – media will always stay a part of this operation environment.
- The role of creating disinformation could increase in the future and be used in our favour, as well as be used or misused by the enemy.
- Operational security has impact to the operation and to providing information.
- Role of proliferation of media is growing up currently, but even more it will grow in the future. Any subject can be the owner, not only government or private, but also small or big communities, groups, including religious ones.
- Emphasize is put to timeliness of information – WEB – SERVERY.
- Role of disinformation in conflict- and post-conflict periods.
- Emphasize to the capabilities of Commanders, HQs, and individual soldiers to cooperate with media – preparation and training the human resources.
- Assessment of impact of argumentation of influence to the operation. How to eliminate the impacts of military – operational security.
- Media will be of the same numbers in the future – not more intelligence officers, maximal up to 10 resources.
- Influencing the public opinion in understanding the enemy.
- More important are the numbers of casualties in the conflict rather than the interest of global trends.

Report from Brno Czech Republic S3:

Introduction

On 16 April 2009, the JO 2030 Solution Workshop was conducted at the University of Defence of Brno in the Czech Republic. The Workshop was conducted in the Czech language as national contribution for the support of LTSS JO 2030 and led by the DDPS[3] Branch Head of ISDS UD[4], LtCol. Ivo Pikner, Ph.D. This was the third Czech national Solution Solicitation Session, the only one topic of Solution Solicitation Sessions focused to problems of role of information and the media was being dealt with in the Seminar.

Aim of the Seminar was to outline the role of the media within the time horizon 2025 – 2030. The Seminar attendees presented, based on their theoretical knowledge and practical experiences their attitudes on what a role the media will play in influencing the outcomes of operations. Recommendations were presented at the conclusion of discussion, on what capabilities the NATO should dispose so that the expanding of distorted information is prevented as such information influence the public opinion unfavourably thus the result of operation.

Workshop Approach and Organization

- The Brno Workshop used a different approach – came out from the experiences from organizing previous Solution Solicitation Sessions.
- S3 – TIC – topics, focused to one field (info and media) were selected in advance.

[3] The Department of Defence Planning Studies.

[4] Institute for Strategic and Defence Studies of the University of Defence.

- Particular organizations and experts dealing with mentioned topics were addressed (approximately one month) in advance.
- Basic information on LTSS JO 2030 were part of invitation pack (A-list TICs were not included).
- In respect to the estimated number of attendees the S3 was not divided to break-out sessions and the Seminar was run in one unit.
- Moderated discussion was held in the first part of the Seminar to evoke the atmosphere of conducting future operations, whilst in the second part the discussion was aimed to get the answers to the questions presented.
- S3 was recorded by note-takers.

Observations

Inputs – historical to the present day:

- Development of the quality and speed of delivering the information to public was always primarily influenced by the science and development of technology.
- Speed of delivery of information was always a factor of possibility of influencing the public opinion (initial information).
- Technology advance in the field of information science result gradually to the consequence that the media has become one of the resources of intelligence (Open Source Intel).
- Currently, it has practically no meaning to keep some kinds of information from the operation area hidden. The newspaper people can always reach the information they seek (or they model it).

Basic way of influencing the public opinion is to assure the provision of information through trained members of the Armed Forces. Other way is to train all members, even at tactical level, on what kind of information the soldiers can provide to the media and what is restricted.

The media have currently sufficient quantity of resources and adequate technology enabling them to inform the public timely.

Prevailing trend of the work of media is the continuous acceleration of the transmission of information from the source to the consumer. This speed, however, result in the fact that the information provided to public do not need to ne absolutely correct and they require corrections. Creating our own capabilities of how to provide the information, e.g., by establishing our own TV channel, will work as one from resources for the media.

Trends for future:

- It is foreseeable that the media will keep their own independence even in a long-term horizon. They will cooperate with the military as with one from the resources of information.
- It can not be expected that further development of technology will be the crucial factor in the field of media. Means of mass communication might be a bit smaller by dimensions or a bit faster but fundamental change is improbable.
- Far bigger stress will be put to the speed of providing the information. Media will, without any doubt, become a source of information for the enemy.
- Development of internet and up-to-date technologies lead even nowadays to “amateurization” of media (practically, everybody can be a journalist today).

- Development of internet servers will lead to further pressure on the speed of providing the information. Internet will lead to far bigger visualization of information.
- Making our own capabilities for Alliance seems to be as very probably for the future, especially with respecting the big competition that exists even these days actually.
- System of preparation and pertinent training of the members of military and PR seems to be rather more effective.
- Role of media in operations around 2030 will not be less significant; it will rather grow up on the contrary. It is possible to assess that possible reduction of significance of "traditional media" to come and consequent increase of other means of media linked to internet and to new forms of distribution or processing the information.

It is possible to make out the influence for conducting the operation of:

a) Friendly media, of relatively positive thinking, whose impact are the most significant for influencing the public opinion in the capital, but, on the other hand, affecting the adversary as well.

b) Media of the adversary/adversaries, with very disputable influence to the population and public opinion within the area of operation (attitudes of such media depend on the type and/or reason of the armed intervention).

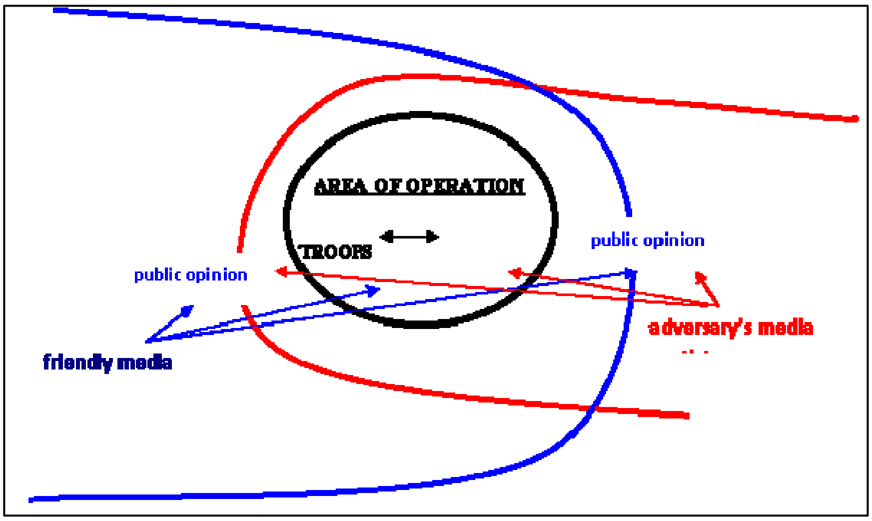

Figure H-3: Influence of Media to Future Operations.

Media will continue to be a significant factor of the success of the operations, it is necessary to consider many of the factors that are contained in the following diagram, Figure H-4.

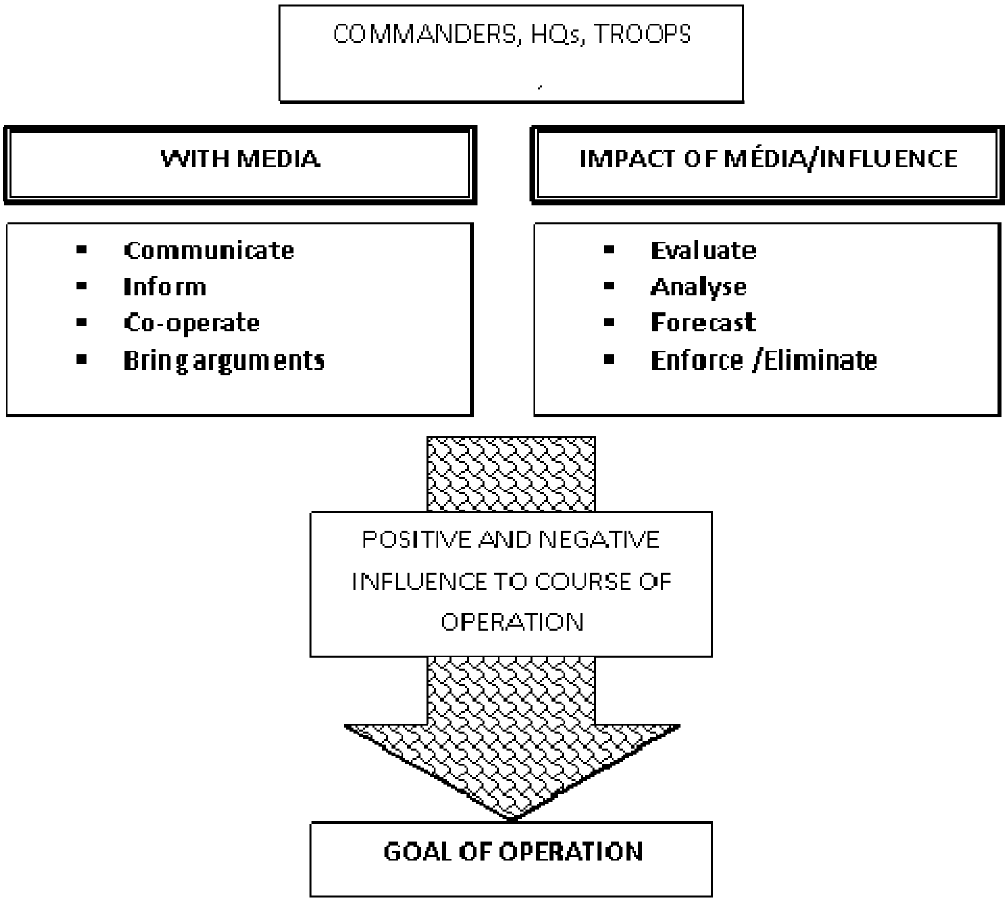

Figure H-4: Diagram of Media Factors that Can Affect an Operation.

From what is stated above, it is necessary to conclude what capabilities are necessary to keep, enforce, or gain.

Outputs from Discussion

- The "War Of Media" in all fields of human activities is going on currently.
- Military will have to cooperate and be helpful to the newspapermen in providing information, both during post-conflict period as well as in the course of conflict. Military will have to perform actively when providing information to public via media, but also via own PSYOPS.
- Newspapermen are and will stay, as well as the soldiers will, under pressure of 24/7 time frame (acting non-stop).
- The needs of possibility of transmission of information from anywhere and at any time with the top quality are being dealt nowadays already, and technologies are available as well (access to internet and/or satellite communication). Possibility of broadcasting and transmission of information from anywhere in the world are solved already.
- One workstation for transmission of information from anywhere for a single-member team is currently easily available.
- Sound (audio) will stay far more important than picture (visualisation).
- Pressure to information update will be far more emphasized in the future than the quality.

- Need of solve technologically (both SW and HW) the capability of analyzing information from increasing number of resources and information themselves (information boom, congestion) is rising for the future. Selection of some resources (reliable – indexing of resources).
- Official linkage – interconnection of information resources with users – official information automatically.
- Role of law and legal loyalty of the people versus newspaper praxis versus loyalty of media will grow up.
- Communication technology determining technological possibilities are not a problem now – the problem is a human being.
- Media of the adversary side will always influence the environment of operation. As a result of this, future capability of separate the information for "backyard" and for operation comes out (INFOOPS, PSYOPS).
- Complex environment of EBAO – media will always stay a part of this operation environment.
- The role of creating disinformation could increase in the future and be used in our favour, as well as be used or misused by the enemy.
- Operational security has impact to the operation and to providing information.
- Role of proliferation of media is growing up currently, but even more it will grow in the future. Any subject can be the owner, not only government or private, but also small or big communities, groups, including religious ones.
- Emphasize is put to timeliness of information – WEB – SERVERY.
- Role of disinformation in conflict and post-conflict periods.
- Emphasize to the capabilities of Commanders, HQs, and individual soldiers to cooperate with media – preparation and training the human resources.
- Assessment of impact of argumentation of influence to the operation. How to eliminate the impacts of military – operational security.
- Media will be of the same numbers in the future – not more intelligence officers, maximal up to 10 resources.
- Influencing the public opinion in understanding the enemy.

More important are the numbers of casualties in the conflict rather than the interest of global trends.

S22 – DRDC Suffield

Notes from Study Leader:

- Security of info in the battlefield.
- Media in 2030 will have many instantaneous feeds.
- Permanent persistent all encompassing surveillance will become a reality.

S24 – DRDC Toronto

Notes from Study Leader:

- Research into understanding human heuristics and biases and persuasion.
- What effects do you want and how do you encourage their attainment?

Technology Focus Areas

- Media and societal influence studies.
- Human perceptions and heuristics studies.
- Trade-off between info-ops, disinformation and trust and loyalty objectives in an operation.

H.24.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Polling and surveying techniques and tools required to verify effectiveness of media strategies.

Technology Focus Areas

- Tool development.

Solutions

- None identified.

H.25 CAPABLE OF EXPLOITING INFORMATION SPACE FOR DISINFORMING OPPONENTS

H.25.1 Theme-Issue-Capability Description

TIC 17.3.2 – The Role of Information and the Media

The media has become instrumental in developing the context for the public audiences that affect the Alliance. The pervasive 24/7 media cycle will continue to create the ‘CNN effect’ where strong emotional content can engender public reaction which may affect political and military decision-making at all levels of command. There is a symbiotic relationship between the military and the media in that the media requires access and information and the military needs the media to communicate with the public. The increased instantaneous access to information available to the public will be a serious consideration in the future as public perception can drive constraints on both the political and military levels.

Issue – Media as an Intelligence Source for the Enemy

The proliferation of media and mediums through which information related to operations can be accessed has significantly increased the use of media reports as sources for intelligence. Adversaries have used traditional media reports, as well as more non-traditional sources such as YouTube and Google, to access geographic data and receive results of attacks and assessments of the quality of tactics. Ambient intelligence?

Capable of exploiting information space for disinforming opponents.

H.25.2 JO 2030 Phase IV Out Reach Results

This TIC was not the subject of any of the 25 Solicitation Sessions.

H.25.3 JO 2030 Multi-National Exercise – Inputs

Explorations

- Don’t do it!
  - Maintain legitimacy.
  - Promulgate un-biased, free press.

Technology Focus Areas

- None identified.

Solutions

- Enable access to free media:
  - Distribution of radios.
  - Promulgate internet access.

Table H-4: The JO 2030 List One Set of TFAs by Capability.

Cap #	Capability Description	TFA #	Technology Focus Areas
1	Capable of shaping the 'home front' in the grey zone between peace and conflict	1	Conflict studies, underlying drivers.
		2	Media and perception studies.
		3	Studies of group and societal influence and behaviour.
		4	Socio-cultural cause-effect studies/models.
		5	Studies of societal dynamics, stability and influencers.
		6	Macro human, social, cultural behavioural studies/models.
		7	Public perception issues.
		8	Cognitive studies (potentially building on ongoing research within the fields of communication technology and marketing strategy).
2	Capable of generating coherent and integrated policy options	No TFAs were identified for this capability.	
3	Capable of developing, assessing and implementing standardised business rules and practices among military, industry, NGO, IO and other entities	9	Studies on organizational trust and relationship building.
		10	Organizational motivation.
		11	Social capital studies.
		12	Build better models of outsourcing.
		13	How far do we decompose services? If we allow a very high degree of specialisation we can have specialist firms do a very effective and efficient job within their area, but it could become costly to integrate those services back into a complete, functioning system. Where do the trade-offs lie?
		14	Based on such models, what do we optimise? Is it just cost, or is it also the total system robustness, trust between actors, etc.? What are the trade-offs?
		15	Multi-agent modelling is one tool that could be used for this, combined with optimisation techniques.
		16	Explore reach-back in new areas. Long-distance maintenance, the expert is back home, use remotely controlled robots (or humans) to the repairs in the field.
4	Capable of establishing and maintaining communication channels and liaison relationships with potential service providers/partners prior to the commencement of operations	17	Tactics, techniques and procedures.
		18	Tool development.
		19	Multi-level security.

Cap #	Capability Description	TFA #	Technology Focus Areas
5	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour	20	Tools to validate data entry, i.e., stress level indications of voice prints, multi-source consistency checking, multi-level fact checking.
		21	Semi-autonomous web or media content monitoring and analysis.
		22	Agreed to framework for initiating and building a focused knowledge base of high fidelity adapted for the operation, location and circumstances at hand.
		23	Agreed to knowledge base standards.
		24	Persistent webs of sensors and communications.
		25	Immersive training environments, games for decision-makers.
		26	M&S support to the development, communication of, and ongoing analysis of a plan or situation for the decision-maker.
		27	How does one system 'trust' another, security and accuracy of information?
		28	Matrix view and analysis of all participants' capabilities, needs, and values.
		29	Biometric identification at short, medium or long range.
		30	Fuzzy logic for autonomous systems.
		31	One too many – what are the rules and interfaces for the future one man controlling many machines?
		32	Study the relation between personality profiles and the behaviour and decision of a decision-maker.
		33	Autonomous learning.
		34	Evolutionary algorithms.
		35	Swarm intelligence.
		36	Human-robot interaction.
		37	Encoding confidence levels and other providence information with the data incorporated into database.
		38	Data mining.
		39	Agent-based modelling.
		40	Reach back capability.
		41	Encoding cultural data.
		42	Multi-level security.
		43	Firewalls.
		44	Artificial intelligence.
		45	Search techniques.

Cap #	Capability Description	TFA #	Technology Focus Areas
5	Capable of building a common, shared holistic knowledge base of the operational environment and identifying a potential adversary's strengths, vulnerabilities and potential behaviour (cont'd)	46	Metadata labelling and management.
		47	Metadata management.
		48	IT tool development.
		49	Knowledge management.
		50	Tool development.
		51	Semantic search engine.
		52	Language translation.
		53	Video capture, video recognition and analysis.
		54	Predictive tools.
		55	Filtering tools.
		56	Computational science.
		57	Image search, recognition, analysis.
		58	Encoding cultural information.
		59	Presenting cultural cues to Commanders in the field in real time.
		60	Accessing social sciences.
		61	Translation of text, audio and video.
		62	Metadata management and labelling.
		63	Search tools.
		64	Metadata management and labelling.
		65	Real-time data push.
		66	Image search and analysis.
		67	Image tools.
		68	Decisions tools.
		69	Biometrics.
		70	Modelling tools.
		71	Metadata management and labelling.
		72	Multi-level security.
6	Capable of measuring, analysing, predicting and anticipating risk within a complex environment	73	Business risk analysis studies.
		74	Multi-level information security systems.
		75	Mixing and matching and exploiting multiple networks, multi-network studies.
		76	Inter-agency exercises.
		77	Value of timely and accurate information.

Cap #	Capability Description	TFA #	Technology Focus Areas
6	Capable of measuring, analysing, predicting and anticipating risk within a complex environment (cont'd)	78	Tools and procedures to build situational awareness rabidly.
		79	Promote SKUNK works – feed good ideas but keep them away from larger organisations.
		80	Embed risk mitigating policies and process into the logic and control functions of the technology.
		81	Persistent observation and communication.
		82	Natural user interface.
		83	How do issues involving high or low trust levels influence risk?
		84	Data filtering techniques.
		85	Pattern fitting and anomaly analysis to find early indications of state changes in a situation.
		86	Algorithm development, an area of great promise but very little advancement over past 40 yrs.
		87	Managing conflict at the margins.
		88	Integrate many risks – political-economic-financial-technology-infrastructure partnership risk.
		89	Studies of the known, unknown, and unknowable and that reduce the latter two.
		90	Risk, how pressing is the risk, how existential is it?
		91	Acceptable risk and return studies.
		92	Studies of assessing, perceiving, and responding to risk both individually and as a group.
		93	Policy legal issues in coming clash of persistent social surveillance.
		94	Context awareness and dual-use pervasive reasoning.
		95	Use of ambient intelligence and pervasive computing to increase awareness and reduce risk.
		96	Long-term technology evolution is another factor to be monitorized in order to assess their systemic implications in future scenarios. This will allow prediction and anticipation of risks about the use of these technologies in military or dual-use applications.
		97	Symbolic or semantic representation of risks and how humans, teams, and organisations/society perceive and react to them.
		98	Cognitive psychology or social psychology research into group risk perception and behaviour.
		99	Development of computational models capable of taking individual risk profile information (and other factors), and simulating team performance against an objective (addresses tactical risk, assists in team formation and COA development).

Cap #	Capability Description	TFA #	Technology Focus Areas
6	Capable of measuring, analysing, predicting and anticipating risk within a complex environment (cont'd)	100	Models to map risk profiles' and techniques to deal with those in a multi-agent 'comprehensive approach' environment.
		101	Investigation of leading indicators to / signals for uncertain events for early warning.
		102	Meta-modelling of 'security status'.
		103	Development of information presentation models, with trustworthiness of sources built into weightings and priorities; for use by decision-makers.
		104	Societal resilience modelling.
7	Capable to assess and implement the structures and processes for planning / decision-making / activity coordination / feedback across the various actors in a comprehensive approach	105	Development of advanced comprehensive planning and decision support tools/models (potentially combining both analytic and preferential approaches).
		106	Potentially aided by research into the discipline of "Critical Thinking".
		107	Improved performance assessment tools/methodologies (increase speed and accuracy, reduce resource requirements, etc.).
		108	Research into alternative/efficient "management" constructs and structures (potentially involving organizational theory and concepts such as "focus and convergence" vice traditional C2).
8	Capable of acting in dynamic 'value chains' with a variety of potential partners	109	Advancing or changing concepts of command and control.
		110	Organizational behaviour or org theory research into new forms of organization which are agile, maintain clear lines of communication, and have authority to operate across Ministries/ Departments.
		111	'Service-Oriented Architecture' – paradigm in a military context.
		112	Game theory-based models where agents with different value structures and outcome pay-offs collaborate; look for insights into effective teaming with "others".
		113	Legal and/or ethical research – under what conditions do which set of laws prevail and what does this imply for: contracted security, NATO forces, commercial logistics?
		114	Social networking as a means of reaching potential partners or niche providers.
9	Capable of defining unambiguous Rules Of Engagement (ROEs)	115	Different decision-making approaches – robotic, Boolean, Bayesian.
		116	Coding values such as loyalty or trust in autonomous systems, coding for different value sets or laws for different Nations or situations.
		117	Which programs should not be researched because they are inherently too dangerous?

Cap #	Capability Description	TFA #	Technology Focus Areas
9	Capable of defining unambiguous Rules Of Engagement (ROEs) (cont'd)	118	Can the legal and ethical world anticipate the coming technology challenges and changes or only lag them?
		119	Information flow – need to improve man-machine and machine-machine interfaces.
		120	Information quality in autonomous decision-making – constraining potential courses of action for autonomous systems depending on the availability and quality of information.
		121	Improving bandwidth availability.
		122	Dominating bandwidth availability.
		123	Minimum regret rules of engagement for autonomous systems.
		124	Verification and validation of complex systems.
		125	Investigate real-time verification and validation.
		126	Investigate "Adjustable Autonomous Policy Management" in which policies are verified and validated and an autonomous system's transition between policies is monitored and controlled.
10	Capable of developing flexible and adaptive leaders	127	Extra-organisational relationship studies.
		128	Organizational studies; clash between value set of a C2 organization and a collaborate and consensus organization.
		129	How will autonomous units or robots be led?
		130	Virtual reality.
		131	Organizational theory.
		132	Social psychology (types of leadership) – transformational, transactional, authoritarian, charismatic.
		133	Knowledge management methods and tools.
		134	Community of practice websites (e.g., US Army Captain's website).
		135	Decision-making support (knowledge / data sharing).
		136	Interest prediction.
		137	Cooperation opportunity identification.
11	Capable of adapting organizational structures to reflect changing circumstances and evolving objectives	138	Data fusion.
		139	Evolving place and role of military organizations in relation to the societies or Nations they support.
		140	Evolving command structures, information flow patterns, and levels of decision-making.
		141	Environmental data collection.
		142	Critical event assessment small units will need to receive timely assessments of the effect of engagements.

Cap #	Capability Description	TFA #	Technology Focus Areas
11	Capable of adapting organizational structures to reflect changing circumstances and evolving objectives (cont'd)	143	Identifying appropriate metrics for the assessment of the event.
		144	Identifying ontology and taxonomies for metadata for classifying and archiving the event.
		145	Remote analysis centre.
		146	Developing models to assess the lessons learnt events in order to determine their generic applicability.
		147	Production facility.
		148	Systems to artificially manipulate imagery and other supporting elements of the lesson learnt packet.
		149	Generate lessons learnt format requirements.
		150	Systems to generate extrapolations from lessons learnt.
		151	Systems to distribute lessons learnt in a timely manner.
		152	Systems to receive the lessons learnt and broadcast it to the small unit or unit members.
		153	Systems to monitor the use of the lessons learnt.
		154	Systems to monitor the effectiveness of the implementation of lessons learnt and to provide prompt feedback to the remote analysis centre.
12	Capable of gathering, analysing and disseminating lessons learned in a timely fashion	155	Role and impact of evolving social networking paradigms.
		156	Transformation of voice into a written reports database.
		157	Automatic ontology generation where there is a distinction between search and sort ontologies for data mining.
		158	Knowledge representation (including time history of info/ knowledge).
		159	Ontologies to help relate lessons learned with other information (planning, situational awareness).
		160	AI for automated extraction of lessons learned.
		161	Multi-level analysis search engine for visual info.
		162	Capturing of voice reports into written reports database, with automatic keywords recording for later extraction.
		163	Lessons learned database – TFA extraction out of database (now search engine triggered by text; future – search engine triggered by voice (/brain)).
		164	Visualization.
		165	Data mining speech to text linked with videos.
		166	Automated data mining through algorithms.
		167	Social networking for lessons learned.

Cap #	Capability Description	TFA #	Technology Focus Areas
13	Capable of empowering society / local communities to deal with the risks associated with the proliferation of dual-use technology	168	Resilience engineering.
		169	Self-regulating or evolving organisations or societies.
		170	Improving capability acquisition strategies and processes.
		171	Rapid change in the commercial world vice reluctant change in the military world, change process analysis.
		172	Gaming as a whole – multi-agent systems, biometrics, group dynamics.
		173	Knowledge management (not just information gathering or IT piece of managing knowledge).
14	Capable of enabling an efficient support chain from home base to point of use in an operation within an integrated multi-national logistic environment	No TFAs were identified for this capability.	
15	Capable of researching and executing strategies that mitigate the need for large numbers of forces	174	Biochemical and bio-mechanical enhancement and augmentation of the warfighter.
		175	One strategy is smart robotics – use autonomous robots in support functions and/or warfighting roles.
		176	One reason numbers are dwindling is that each platform/soldier become more capable, hence more expensive. The drive for increasing capabilities is that we want to make sure our soldiers win – and survive. We therefore need the best weapon systems, the best armour, the best electronic support measures, etc. We could break this cost-capability spiral if we substitute many inexpensive, single-role, unmanned systems for the big, multi-role, expensive manned systems. Those we can afford to lose ("suicide-systems" for conventional warfare).
		177	Improved autonomous monitoring of borders, HVAs, wide-area coverage, etc. Need research into sensors and detection algorithms.
		178	Need more research into the collaboration between man and machine. People, robots and reach-back will all be elements in future ops. How to optimise the way these operate together and communicate.
		179	Utilize existing (but untried / not legally cleared) technologies that enhance defensive capabilities, i.e., various non-lethal weapons: sonic; laser dazzler; and electro-magnetic weapons (EMP, HPM).

Cap #	Capability Description	TFA #	Technology Focus Areas
16	Capable of forward operational planning for complex endeavours across the different stages and in a multi-agency environment	180	Methods/tools to identify trust (on an intercultural dimension) and incorporate it into operational planning.
17	Capable of acting without access to cyberspace	181	Complexity science and cyberspace security studies.
		182	Emphasis probably better spent on ensuring access through robustness, redundancy, protection.
		183	"Archaic" fallback methods (paper maps, supply forms, manual navigation aids).
18	Capable of acting without access to space assets	184	Micro-satellites, alternative space vehicles.
		185	Redundancy measures.
		186	Drone-based navigation and communication systems.
		187	Smart dust and pollen to build ad hoc connectivity.
		188	Networked balloons and air assets.
		189	Protection of ground-based assets.
		190	Inertial systems based on N-MEMS.
		191	Distributed cognitive systems.
		192	Ionosphere refraction index prediction.
		193	Swarm of autonomous, networked UAVs. With advanced sensors and image/map processing these could provide navigation aid, surveillance and comms. Each of them could be small and/or specialised and hence be relatively cheap. Research areas (theoretical research, simulator trials, small-scale tests ongoing, but system is not fielded, mainly because FAA and society are not ready).
		194	Peer-to-peer collision avoidance.
		195	Image processing algorithms.
		196	Collaborative/networked, but autonomous operations.
		197	Enabling technologies – enhanced batteries (high capacity, long endurable, rechargeable).
19	Capable of establishing how military activities contribute to achieving political objectives and end-states, and vice versa	198	Process and policy studies particularly across changing and shifting political dimensions.
		199	Conflict management studies – alignment or mis-alignment of various national interests with a pan NATO interest.

Cap #	Capability Description	TFA #	Technology Focus Areas
20	Capable of conducting civil-military cooperation in an inter-agency environment	200	Cross cultural psychology studies.
		201	Relationship and network building – mentoring and trust versus master and servant.
		202	Learning and info sharing.
		203	Relationship building based on growing commonalities and less on managing differences.
		204	Auto language translation incorporating other sensors such as gestures, body language, eye movement, etc.
		205	Auto speech to text transcription (for subsequent storage).
		206	Contextual analysis and intent recognition tools.
		207	Social studies designed to identify and develop cultural awareness (e.g., social modelling/networking, anthropology).
		208	Social studies related to how organizations and individuals can efficiently interact when they have competing goals and objectives.
		209	Social studies related to rapidly building trust between organizations and individuals with disparate goals, cultures and objectives.
		210	Research to identify human characteristics that build trust.
		211	Training – rapid and efficient methods.
		212	Develop better cognitive understanding of learning.
		213	Develop/adapt multi-player gaming to our needs (existing RTO study on application of gaming in the military?).
		214	Develop training in how to interact (involving knowledge/ sensitivity training about disparate cultural norms).
		215	Research into complexity theory – may lead to the development of efficient ways of working together.
		216	Organizational theory.
		217	Research into alternative/efficient “management” constructs and structures (potentially involving concepts such as “focus and convergence” vice traditional C2).
		218	Research on the efficient development, maintenance and interrogation of large knowledge bases.
		219	Inter-agency COP potentially supported by “Green Force Tracker”, “OnStar” or GPS / cell phone exploitation such as “Google Tracking”.
21	Capable of formulating and executing shared and realistic actions	No TFAs were identified for this capability.	

Cap #	Capability Description	TFA #	Technology Focus Areas
22	Capable of collecting in a timely manner the imagery, data, information and intelligence on opponents and the environment required to meet Alliance end-user requirements	220	Cognitive radios and spectrum exploitation.
		221	Bandwidth constraints and data compression.
		222	Network management strategies.
		223	Data-information-knowledge chain analysis in a distributed network – information needs vs. information generation vs. information location.
		224	Studies on FMRI / polygraphs / physiological monitoring / facial change monitoring.
		225	Soft science including psychopathology and psycho sociology.
		226	Man machine interface.
		227	Bandwidth.
		228	Computational science.
		229	Artificial intelligence.
		230	Metadata management and labelling.
		231	Tactics, techniques and procedures.
		232	Tool development.
		233	Energy science and engineering.
23	Capable of undertaking in-depth foresight analysis to develop models of the future security environment	234	Organizational alignment and structure analysis.
		235	Organizational theory.
		236	Complexity theory.
		237	Stochastic estimation.
		238	Agent-based modelling.
		239	Quantum computing.
		240	Alternatives to silicone-based computing devices.
		241	Risk assessment models.
		242	Data and information management technology covering very diverse sources.
		243	Data mining.
24	Capable of designing effective media strategies	244	Media and societal influence studies.
		245	Human perceptions and heuristics studies.
		246	Trade-off between info-ops, disinformation and trust and loyalty objectives in an operation.
		247	Polling and surveying techniques and tools required to verify effectiveness of media strategies.

Cap #	Capability Description	TFA #	Technology Focus Areas
25	Capable of exploiting information space for disinforming opponents	No TFAs were identified for this capability.	

Annex I – TABLES OF FIELDS OF SCIENCE

The following two tables are the tables of the Fields of Science as extracted from Wikipedia in March 2010. Table I-1 is a summary table of the major headings of the Fields of Science and Table I-2 is a more complete table that includes these major headings along with a number of more focused fields of science grouped under each of the major headings. While this taxonomy is generally agreed to in the English speaking world, Wikipedia is known to be a 'living' source of information and, as such, is subject to change, so this table was copied into this Annex for reference purposes. At the time of writing this paper the reference for this table was http://en.wikipedia.org/wiki/Fields_of_science#Anthropology.

Fields of Science are widely-recognized categories of specialized expertise within **science**, and typically embody their own **terminology** and **nomenclature**. Each field will commonly be represented by one or more **scientific journal**, where **peer reviewed** research will be published.

Table I-1: Summary Table of the Major Headings of the Fields of Science.

- 1 Natural sciences
  - 1.1 Physical Sciences
    - 1.1.1 Chemistry
    - 1.1.2 Physics
    - 1.1.3 Astronomy
    - 1.1.4 Earth sciences
    - 1.1.5 Environmental sciences
  - 1.2 Life Sciences / Biology

- 2 Formal sciences
  - 2.1 Computer sciences
  - 2.2 Mathematics
  - 2.3 Statistics
  - 2.4 Systems science

- 3 Social sciences
  - 3.1 Anthropology
  - 3.2 Economics
  - 3.3 Psychology
  - 3.4 Geography
  - 3.5 Philosophy
  - 3.6 Political science
  - 3.7 Sociology

- 4 Applied sciences
  - 4.1 Agronomy
  - 4.2 Architecture
  - 4.3 Cognitive sciences
  - 4.4 Education
  - 4.5 Engineering
  - 4.6 Health sciences
  - 4.7 Management
  - 4.8 Military Science

Table I-2: Table of Major and Lower Levels of the Fields of Science.

NATURAL SCIENCES

- Fields within the natural sciences.

Physical Sciences

Chemistry

- Analytical chemistry
- Biochemistry
- Computational chemistry
- Electrochemistry
- Geochemistry
- Inorganic chemistry
- Materials science
- Medicinal chemistry
- Organic chemistry
- Polymer chemistry
- Physical chemistry
- Quantum chemistry
- Spectroscopy
- Stereochemistry
- Thermochemistry
- Thermodynamics

Physics

- Acoustics
- Agrophysics
- Atomic, molecular, and optical physics
- Biophysics
- Computational physics
- Condensed matter physics
- Cryogenics
- Dynamics
- Electricity and magnetism
- Electronics
- Fluid dynamics
- Geophysics
- Materials physics
- Mathematical physics
- Mechanics
- Nuclear physics
- Optics
- Particle / High energy physics
- Plasma physics
- Polymer physics
- Quantum physics
- Statics
- Solid state
- Thermodynamics
- Vehicle dynamics

Astronomy

- Archaeoastronomy
- Astrobiology
- Astrochemistry
- Astrodynamics
- Astrometry
- Astrophysics
- Cosmochemistry
- Cosmology
- Extragalactic astronomy
- Galactic astronomy
- Physical cosmology
- Planetary geology
- Planetary science
- Solar astronomy
- Stellar astronomy

Earth Sciences

- Atmospheric sciences
- Biogeography
- Cartography
- Climatology
- Coastal geography
- Geodesy
- Geography
- Geology
- Geomorphology
- Geostatistics
- Geophysics
- Glaciology
- Hydrology
- Hydrogeology
- Mineralogy
- Meteorology
- Oceanography
- Paleoclimatology
- Paleontology
- Petrology
- Limnology
- Seismology
- Soil science
- Topography
- Volcanology

Environmental Sciences

- Ecology
- Freshwater biology
- Marine biology
- Parasitology
- Population dynamics
- Environmental chemistry
- Environmental soil science
- Environmental geology
- Toxicology

Life Sciences / Biology

- Anatomy/morphology
- Astrobiology
- Biochemistry
- Bioinformatics
- Biophysics
- Botany
- Bryology
- Mycology
- Lichenology
- Palynology
- Phycology (Algology)
- Cell biology / cytology
- Chronobiology
- Conservation biology
- Developmental biology
- Embryology
- Gerontology
- Epidemiology
- Ecology
- Evolution/evolutionary biology
- Evolutionary developmental biology
- Genetics
- Genomics
- Proteomics
- Population genetics
- Microbiology/ bacteriology
- Molecular biology
- Structural biology
- Physiology
- Immunology
- Kinesiology
- Neuroscience
- Histology
- Systematics
- Cladistics
- Phylogeny
- Taxonomy
- Virology
- Zoology
- Arachnology
- Acarology
- Entomology
- Myrmecology
- Ethology
- Helminthology
- Herpetology
- Ichthyology
- Malacology
- Mammology
- Cetology
- Physical anthropology
- Nematology
- Ornithology

FORMAL SCIENCES

- Fields within the formal sciences.

Computer Sciences

- Theory of computation
- Automata theory (formal languages)
- Computability theory
- Computational complexity theory
- Concurrency theory
- Algorithms
- Randomized algorithms
- Distributed algorithms
- Parallel algorithms
- Data structures
- Scientific visualization
- Computational geometry
- Software engineering
- Formal methods (formal verification)
- Programming languages
- Programming paradigms
- Object-oriented programming
- Functional programming
- Program semantics
- Type theory
- Compilers
- Human-computer interaction
- Computing in mathematics, natural sciences, engineering and medicine
- Numerical analysis
- Algebraic (symbolic) computation
- Computational number theory
- Computational mathematics
- Scientific computing (computational science)
- Computational biology (bioinformatics)

Computer Sciences (cont'd)

- Computer architecture
- VLSI design
- Operating systems
- Computer communications (networks)
- Information theory
- Internet, World Wide Web
- Wireless computing (mobile computing)
- Computer security and reliability
- Cryptography
- Fault-tolerant computing
- Distributed computing
- Grid computing
- Parallel computing
- High-performance computing
- Quantum computing
- Computer graphics
- Image processing
- Concurrent programming languages
- Information science
- Database
- Relational database
- Distributed database
- Object database
- Multimedia, hypermedia
- Data mining
- Information retrieval
- Artificial intelligence
- Automated reasoning
- Computer vision
- Machine learning
- Artificial neural network
- Natural language processing (computational linguistics)
- Expert systems
- Robotics
- Computational physics
- Computational chemistry
- Computational neuroscience
- Computer-aided engineering
- Finite element analysis
- Computational fluid dynamics
- Computing in social sciences, arts and humanities, professions
- Computational economics
- Computational sociology
- Computational finance
- Humanities computing (digital humanities)
- Information systems (business informatics)
- Information technology
- Management information systems
- Health informatics

- See also Branches of Computer Science and ACM Computing Classification System

Mathematics

- Algebra
- Group theory
- Group representation
- Ring theory
- Field theory
- Linear algebra (vector space)
- Multi-linear algebra
- Lie algebra
- Associative algebra
- Non-associative algebra
- Universal algebra
- Homological algebra
- Category theory
- Lattice theory (order theory)
- Differential algebra
- Analysis
- Real analysis
- Probability theory
- Measure theory
- Ergodic theory
- Stochastic process
- Geometry and topology
- General topology
- Algebraic topology
- Geometric topology
- Differential topology
- Algebraic geometry
- Differential geometry
- Projective geometry
- Affine geometry
- Non-Euclidean geometry
- Convex geometry
- Discrete geometry
- Trigonometry
- Model theory
- Recursion theory
- Modal logic
- Intuitionistic logic
- Applied mathematics
- Mathematical statistics
- Probability
- Approximation theory
- Numerical analysis
- Optimization (mathematical programming)
- Operations research
- Linear programming
- Dynamical systems
- Chaos theory
- Fractal geometry
- Mathematical physics

Mathematics (cont'd)

- Calculus
- Complex analysis
- Functional analysis
- Operator theory
- Non-standard analysis
- Harmonic analysis
- p-adic analysis
- Ordinary differential equations
- Partial differential equations
- Number theory
- Analytic number theory
- Algebraic number theory
- Geometric number theory
- Logic and foundations of mathematics
- Set theory
- Proof theory
- Quantum field theory
- Statistical mechanics
- Information theory
- Cryptography
- Combinatorics
- Coding theory
- Graph theory
- Game theory

- See also Branches of Mathematics and AMS Mathematics Subject Classification

Statistics

- Computational statistics
- Data mining
- Regression
- Simulation
- Bootstrap (statistics)
- Design of experiments
- Block design and analysis of variance
- Response surface methodology
- Statistical modelling
- Biostatistics
- Epidemiology
- Multi-variate analysis
- Structural equation model
- Time series
- Reliability theory
- Quality control
- Statistical theory
- Decision theory
- Mathematical statistics
- Probability
- Sample survey
- Sampling theory
- Survey methodology

Systems Science

- Complex systems
- Complexity theory
- Cybernetics
- Biocybernetics
- Engineering cybernetics
- Management cybernetics
- Medical cybernetics
- New cybernetics
- Second-order cybernetics
- Control theory
- Control engineering
- Control systems
- Dynamical systems
- Operations research
- Systems dynamics
- Systems analysis
- Systems theory
- Developmental systems theory
- General systems theory
- Linear time-invariant systems
- Mathematical system theory

SOCIAL SCIENCES

- Fields within the social sciences.

Anthropology

- Anthropology of religion
- Applied anthropology
- Archaeology
- Experimental archaeology
- Historical archaeology
- Linguistic anthropology

Anthropology (cont'd)

- Cultural anthropology
- Ethnobiology
- Ethnography
- Ethnology
- Ethnopoetics
- Evolutionary anthropology
- Medical anthropology
- Physical anthropology
- Psychological anthropology
- Zooarchaeology
- Anthrozoology

Economics

- Macroeconomics
- Microeconomics
- Behavioural economics
- Bioeconomics
- Comparative economics
- Socialist economics
- Development economics
- Economic geography
- Economic history
- Economic sociology
- Energy economics
- Entrepreneurial economics
- Environmental economics
- Evolutionary economics
- Financial economics
- Heterodox economics
- Green economics
- Feminist economics
- Islamic economics
- Industrial organization
- International economics
- Institutional economics
- Labor economics
- Law and economics
- Managerial economics
- Monetary economics
- Neuroeconomics
- Public finance
- Public economics
- Real estate economics
- Resource economics
- Welfare economics
- Political economy
- Socioeconomics
- Transport economics
- Economic methodology
- Computational economics
- Econometrics
- Mathematical economics
- Economic statistics
- Time series
- Experimental economics

Psychology

- See also sub-fields of psychology

- Behaviour analysis
- Biopsychology
- Cognitive psychology
- Clinical psychology
- Cultural psychology
- Developmental psychology
- Educational psychology
- Health psychology
- Humanistic psychology
- Industrial and organizational psychology
- Music therapy
- Neuropsychology
- Personality psychology
- Psychometrics

Psychology (cont'd)

- Evolutionary psychology
- Experimental psychology
- Forensic psychology
- Psychology of religion
- Psychophysics
- Sensation and perception psychology

Geography

- Cartography
- Human geography
- Critical geography
- Cultural geography
- Feminist geography
- Economic geography
- Development geography
- Historical geography
- Time geography
- Political geography and geopolitics
- Marxist geography
- Military geography
- Strategic geography
- Population geography
- Social geography
- Behavioural geography
- Children's geographies
- Health geography
- Tourism geography
- Urban geography
- Environmental geography
- Physical geography
- Biogeography
- Climatology
- Palaeoclimatology
- Coastal geography
- Geomorphology
- Geodesy
- Hydrology/Hydrography
- Glaciology
- Limnology
- Oceanography
- Pedology
- Landscape ecology
- Palaeogeography
- Regional geography

Philosophy

Not considered a science by some thinkers, instead considered a precursor of it. Several fields of philosophy are more directly relevant to the natural and social sciences than others. These include:

- Epistemology;
- Ethics;
- Logic;
- Philosophy of mind; and
- Philosophy of science.

Political Science

- Comparative politics
- Game theory
- Geopolitics and political geography
- Ideology
- Political economy
- Political psychology, bureaucratic, administrative and judicial behaviour
- Psephology (voting systems and electoral behaviour)
- Public administration
- Public policy
- Local government studies* supranational and intergovernmental politics
- Political science of religion
- International relations theory

Sociology

- See also sub-fields of sociology
- Criminology
- Demography

APPLIED SCIENCES

- Fields within the applied sciences.

Agronomy

- Animal husbandry
- Aquaculture
- Agriculture
- Food science
- Forestry
- Horticulture
- Hydroponics
- Permaculture

Architecture

- Architectural engineering
- Architecture
- Building science

Cognitive Sciences

- Cognitive neuroscience
- Cognitive psychology
- Neuropsychology
- Psycholinguistics

Education

Engineering

- Aeronautical engineering
- Aerospace engineering
- Agricultural engineering
- Agricultural science
- Aeronautical engineering
- Computer engineering
- Control engineering
- Electrical engineering
- Industrial engineering
- Computer engineering
- Mechanical engineering
- Mining engineering
- Nuclear engineering
- Polymer engineering
- Mechanical engineering

Engineering (cont'd)

- Aerospace engineering
- Agricultural engineering
- Agricultural science
- Biomedical engineering
- Bioengineering
- Chemical engineering
- Civil engineering
- Control engineering
- Electrical engineering
- Industrial engineering
- Language engineering
- Marine engineering
- Materials engineering
- Mining engineering
- Nuclear engineering
- Polymer engineering
- Software engineering
- Systems engineering

Health Sciences

- Conservation medicine
- Dentistry
- Optometry
- Medicine
- Anatomy
- Dermatology
- Gynecology
- Immunology
- Internal medicine
- Neurology
- Ophthalmology
- Pathology
- Pathophysiology
- Pediatrics
- Pharmacy
- Physiology
- Psychiatry
- Radiology
- Toxicology
- Urology
- Nutrition
- Nursing
- Pharmacology
- Physical therapy
- Veterinary medicine

Management

- Accounting
- Business strategy
- Finance
- Marketing
- Organizational behaviour
- Operations

Military Science

- Military organization
- Military education and training
- Military history
- Military engineering
- Military strategy and tactics

Annex J – TECHNOLOGY FOCUS AREAS LINKED TO FIELDS OF SCIENCE

In building the connections between each of the Set of List One TFAs with the Fields of Science a table of numeric codes associated with each of the 30 different Fields of Science was created and is included as Table J-1 below. Table J-1 is followed by Table J-2 which is the record of the one or more Fields of Science that were associated with each of the 247 List One TFAs.

Table J-1: Table of Linking Codes for the 30 Major Fields of Science.

CODE	Field of Science		
100	Natural Sciences		
110		Physical Sciences	
111			Chemistry
112			Physics
113			Astronomy
114			Earth Sciences
115			Environmental Sciences
120		Life Sciences / Biology	
200	Formal Sciences		
210		Computer Sciences	
220		Mathematics	
230		Statistics	
240		Systems Science	
300	Social Sciences		
310		Anthropology	
320		Economics	
330		Psychology	
340		Geography	
350		Philosophy	
360		Political Science	
370		Sociology	
400	Applied Sciences		
410		Agronomy	
420		Architecture	
430		Cognitive Sciences	
440		Education	
450		Engineering	
460		Health Sciences	
470		Management	
480		Military Science	

Table J-2: Table of TFAs Associated with One or More Major Fields of Science.

Capability #	TFA #	TFA	Field of Science #
1	1	Conflict studies, underlying drivers.	310, 330, 340
1	2	Media and perception studies.	310, 320, 330, 370, 430
1	3	Studies of group and societal influence and behaviour.	300
1	4	Socio-cultural cause-effect studies/ models.	310, 320, 370
1	5	Studies of societal dynamics, stability and influencers.	300
1	6	Macro human, social, cultural behavioural studies/models.	300
1	7	Public perception issues.	300
1	8	Cognitive studies (potentially building on ongoing research within the fields of communication technology and marketing strategy).	112, 210, 310, 430, 470
3	9	Studies on organizational trust and relationship building.	300, 470, 480
3	10	Organizational motivation.	300, 240, 470
3	11	Social capital studies.	370
3	12	Build better models of outsourcing.	240, 470
3	13	How far do we decompose services? If we allow a very high degree of specialisation we can have specialist firms do a very effective and efficient job within their area, but it could become costly to integrate those services back into a complete, functioning system. Where do the trade-offs lie?	240, 470, 480
3	14	Based on such models, what do we optimise? Is it just cost, or is it also the total system robustness, trust between actors, etc.? What are the trade-offs?	230, 240
3	15	Multi-agent modelling is one tool that could be used for this, combined with optimisation techniques.	210, 220, 240
3	16	Explore reach-back in new areas. Long-distance maintenance, the expert is back home, use remotely controlled robots (or humans) to the repairs in the field.	210, 240, 450
4	17	Tactics, techniques and procedures.	240, 470, 480

Capability #	TFA #	TFA	Field of Science #
4	18	Tool development.	200, 450
4	19	Multi-level security.	210, 240, 450
5	20	Tools to validate data entry, i.e., stress level indications of voice prints, multi-source consistency checking, multi-level fact checking.	200, 330, 450, 460
5	21	Semi-autonomous web or media content monitoring and analysis.	210
5	22	Agreed to framework for initiating and building a focused knowledge base of high fidelity adapted for the operation, location and circumstances at hand.	210
5	23	Agreed to knowledge base standards.	210
5	24	Persistent webs of sensors and communications.	200, 450
5	25	Immersive training environments, games for decision-makers.	240, 320, 330, 430, 480
5	26	M&S support to the development, communication of, and ongoing analysis of a plan or situation for the decision-maker.	200, 430, 450, 480
5	27	How does one system 'trust' another, security and accuracy of information?	210
5	28	Matrix view and analysis of all participants capabilities, needs, and values.	210, 310, 320
5	29	Biometric identification at short, medium or long range.	110, 210, 450
5	30	Fuzzy logic for autonomous systems.	210, 240
5	31	One too many – what are the rules and interfaces for the future one man controlling many machines?	210, 240, 310, 350, 450, 480
5	32	Study the relation between personality profiles and the behaviour and decision of a decision-maker.	300, 430
5	33	Autonomous learning.	210, 330, 430
5	34	Evolutionary algorithms.	220
5	35	Swarm intelligence.	200, 450
5	36	Human-robot interaction.	210, 240, 310, 350, 450, 480

Capability #	TFA #	TFA	Field of Science #
5	37	Encoding confidence levels and other providence information with the data incorporated into database.	210
5	38	Data mining.	210
5	39	Agent-based modelling.	210, 220, 240
5	40	Reachback capability.	210, 240
5	41	Encoding cultural data.	210, 310
5	42	Multi-level security.	210, 240, 450
5	43	Firewalls.	210
5	44	Artificial intelligence.	210
5	45	Search techniques.	210, 220
5	46	Metadata labelling and management.	210
5	47	Metadata management.	210
5	48	IT tool development.	200, 450
5	49	Knowledge management.	200, 310, 430, 450
5	50	Tool development.	200, 450
5	51	Semantic search engine.	210, 220
5	52	Language translation.	210, 220, 310, 330, 430
5	53	Video capture, video recognition and analysis.	200, 450
5	54	Predictive tools.	200, 320, 470
5	55	Filtering tools.	210
5	56	Computational science.	210
5	57	Image search, recognition, analysis.	200
5	58	Encoding cultural information.	210, 310
5	59	Presenting cultural cues to Commanders in the field in real time.	210, 310, 340, 480
5	60	Accessing social sciences.	300
5	61	Translation of text, audio and video.	210
5	62	Metadata management and labelling.	210
5	63	Search tools.	210, 220
5	64	Metadata management and labelling.	210
5	65	Real-time data push.	210, 240
5	66	Image search and analysis.	200

Capability #	TFA #	TFA	Field of Science #
5	67	Image tools.	200
5	68	Decisions tools.	210, 240
5	69	Biometrics.	110, 210, 450
5	70	Modelling tools.	200, 450
5	71	Metadata management and labelling.	210
5	72	Multi-level security.	210, 240, 450
6	73	Business risk analysis studies.	200, 320, 470
6	74	Multi-level information security systems.	210, 240, 450
6	75	Mixing and matching and exploiting multiple networks, multi-network studies.	200, 450
6	76	Inter-agency exercises.	470, 480
6	77	Value of timely and accurate information.	200, 470, 480
6	78	Tools and procedures to build situational awareness rabidly.	200
6	79	Promote SKUNK works: feed good ideas but keep them away from larger organisations.	470
6	80	Embed risk mitigating policies and process into the logic and control functions of the technology.	210, 240, 450
6	81	Persistent observation and communication.	200, 450
6	82	Natural user interface.	210, 330, 430
6	83	How do issues involving high or low trust levels influence risk?	200, 320, 350, 470
6	84	Data filtering techniques.	210
6	85	Pattern fitting and anomaly analysis to find early indications of state changes in a situation.	200
6	86	Algorithm development, an area of great promise but very little advancement over past 40 yrs.	210, 220, 240
6	87	Managing conflict at the margins.	310, 340, 360, 470, 480
6	88	Integrate many risks – political-economic-financial-technology-infrastructure partnership risk.	200, 320, 470

Capability #	TFA #	TFA	Field of Science #
6	89	Studies of the known, unknown, and unknowable and that reduce the latter two.	200
6	90	Risk – how pressing is the risk, how existential is it?	200, 320, 470
6	91	Acceptable risk and return studies.	320, 470, 480
6	92	Studies of assessing, perceiving, and responding to risk both individually and as a group.	300, 430
6	93	Policy legal issues in coming clash of persistent social surveillance.	350, 360, 370
6	94	Context awareness and dual-use pervasive reasoning.	330, 430
6	95	Use of ambient intelligence and pervasive computing to increase awareness and reduce risk.	200, 320, 470, 480
6	96	Long-term technology evolution is another factor to be monitored in order to assess their systemic implications in future scenarios. This will allow prediction and anticipation of risks about the use of these technologies in military or dual-use applications.	210, 240, 450, 470
6	97	Symbolic or semantic representation of risks and how humans, teams, and organisations/society perceive and react to them.	200, 300, 430, 470
6	98	Cognitive psychology or social psychology research into group risk perception and behaviour.	310, 330, 340, 370, 430
6	99	Development of computational models capable of taking individual risk profile information (and other factors), and simulating team performance against an objective (addresses tactical risk, assists in team formation and COA development).	210, 240, 430
6	100	Models to map risk profiles’ and techniques to deal with those in a multi-agent ‘comprehensive approach’ environment.	200, 320, 470

Capability #	TFA #	TFA	Field of Science #
6	101	Investigation of leading indicators to / signals for uncertain events for early warning.	200, 320, 480
6	102	Meta-modelling of ‘security status’.	210
6	103	Development of information presentation models, with trustworthiness of sources built into weightings and priorities; for use by decision-makers.	210, 240, 430
6	104	Societal resilience modelling.	310, 320, 370
7	105	Development of advanced comprehensive planning and decision support tools/models (potentially combining both analytic and preferential approaches).	210, 240, 430
7	106	Potentially aided by research into the discipline of “Critical Thinking”.	430
7	107	Improved performance assessment tools/ methodologies (increase speed and accuracy, reduce resource requirements, etc.).	240, 450, 470, 480
7	108	Research into alternative/efficient “management” constructs and structures (potentially involving organizational theory and concepts such as “focus and convergence” vice traditional C2).	300, 240, 470
8	109	Advancing or changing concepts of command and control.	330, 470, 480
8	110	Organizational behaviour or org theory research into new forms of organization which are agile, maintain clear lines of communication, and have authority to operate across Ministries/Departments.	300, 240, 470
8	111	‘Service-Oriented Architecture’ – paradigm in a military context.	470, 480
8	112	Game theory-based models where agents with different value structures and outcome pay-offs collaborate; look for insights into effective teaming with “others”.	200, 320

Capability #	TFA #	TFA	Field of Science #
8	113	Legal and/or ethical research: Under what conditions do which set of laws prevail and what does this imply for: contracted security, NATO forces, commercial logistics.	350, 360
8	114	Social networking as a means of reaching potential partners or niche providers.	300
9	115	Different decision-making approaches – robotic, Boolean, Bayesian.	200
9	116	Coding values such as loyalty or trust in autonomous systems, coding for different value sets or laws for different Nations or situations.	210, 310, 350
9	117	Which programs should not be researched because they are inherently too dangerous?	350, 450, 470, 480
9	118	Can the legal and ethical world anticipate the coming technology challenges and changes or only lag them?	350
9	119	Information flow – need to improve man-machine and machine-machine interfaces.	200, 450
9	120	Information quality in autonomous decision-making – constraining potential courses of action for autonomous systems depending on the availability and quality of information.	200, 450
9	121	Improving bandwidth availability.	112, 240, 450
9	122	Dominating bandwidth availability.	112, 240, 450
9	123	Minimum regret rules of engagement for autonomous systems.	210, 240, 350, 450
9	124	Verification and validation of complex systems.	200, 450
9	125	Investigate real-time verification and validation.	240, 450
9	126	Investigate "Adjustable Autonomous Policy Management" in which policies are verified and validated and an autonomous system's transition between policies is monitored and controlled.	210, 360, 450

Capability #	TFA #	TFA	Field of Science #
10	127	Extra-organisational relationship studies.	310, 340, 370, 480
10	128	Organizational studies – clash between value set of a C2 organization and a collaborate and consensus organization.	300, 240, 470
10	129	How will autonomous units or robots be led?	210, 240, 310, 350, 450, 480
10	130	Virtual reality.	210
10	131	Organizational theory.	300, 240, 470
10	132	Social psychology (types of leadership) – transformational, transactional, authoritarian, charismatic.	310, 370
10	133	Knowledge management methods and tools.	200, 310, 430, 450
10	134	Community of practice websites (e.g., US Army Captain's website).	210
10	135	Decision-making support (knowledge / data sharing).	210, 240, 430
10	136	Interest prediction.	200, 320, 470
10	137	Cooperation opportunity identification.	310, 320, 330, 340
11	138	Data fusion.	210
11	139	Evolving place and role of military organizations in relation to the societies or Nations they support.	310, 340, 370, 480
11	140	Evolving command structures, information flow patterns, and levels of decision-making.	240, 470, 480
11	141	Environmental data collection.	115, 210
11	142	Critical event assessment small units will need to receive timely assessments of the effect of engagements.	210, 240, 480
11	143	Identifying appropriate metrics for the assessment of the event.	210, 240, 320
11	144	Identifying ontology and taxonomies for metadata for classifying and archiving the event.	210, 240, 320
11	145	Remote analysis centre.	200, 470, 480
11	146	Developing models to assess the lessons learnt events in order to determine their generic applicability.	210, 240

Capability #	TFA #	TFA	Field of Science #
11	147	Production facility.	450, 470
11	148	Systems to artificially manipulate imagery and other supporting elements of the lesson learnt packet.	210, 330, 430
11	149	Generate lessons learnt format requirements.	210
11	150	Systems to generate extrapolations from lessons learnt.	210, 330, 430
11	151	Systems to distribute lessons learnt in a timely manner.	210, 330, 430
11	152	Systems to receive the lessons learnt and broadcast it to the small unit or unit members.	210, 330, 430
11	153	Systems to monitor the use of the lessons learnt.	210, 330, 430
11	154	Systems to monitor the effectiveness of the implementation of lessons learnt and to provide prompt feedback to the remote analysis centre.	210, 330, 430
12	155	Role and impact of evolving social networking paradigms.	300, 470, 480
12	156	Transformation of voice into a written reports database.	210
12	157	Automatic ontology generation where there is a distinction between search and sort ontologies for data mining.	210
12	158	Knowledge representation (including time history of info/knowledge).	200, 310, 430, 450
12	159	Ontologies to help relate lessons learned with other information (planning, situational awareness).	210
12	160	AI for automated extraction of lessons learned.	210
12	161	Multi-level analysis search engine for visual info.	210, 240, 450
12	162	Capturing of voice reports into written reports database, with automatic keywords recording for later extraction.	210, 430

Capability #	TFA #	TFA	Field of Science #
12	163	Lessons learned database – TFA extraction out of database (now search engine triggered by text; future: search engine triggered by voice (/brain)).	210, 330, 430
12	164	Visualization.	210, 330, 430
12	165	Data mining speech to text linked with videos.	210
12	166	Automated data mining through algorithms.	210
12	167	Social networking for lessons learned.	300, 210
13	168	Resilience engineering.	240, 450
13	169	Self-regulating or evolving organisations or societies.	300, 470, 480
13	170	Improving capability acquisition strategies and processes.	470, 480
13	171	Rapid change in the commercial world vice reluctant change in the military world, change process analysis.	300, 470
13	172	Gaming as a whole – multi-agent systems, biometrics, group dynamics.	200, 320
13	173	Knowledge management (not just information gathering or IT piece of managing knowledge).	200, 310, 430, 450
15	174	Biochemical and bio-mechanical enhancement and augmentation of the warfighter.	120, 450, 460
15	175	One strategy is smart robotics – use autonomous robots in support functions and/or warfighting roles.	210, 240, 310, 350, 450, 480
15	176	One reason numbers are dwindling is that each platform/soldier become more capable, hence more expensive. The drive for increasing capabilities is that we want to make sure our soldiers win – and survive. We therefore need the best weapon systems, the best armour, the best electronic support measures, etc. We could break this cost-capability spiral if we substitute many inexpensive, single-role, unmanned systems for the big, multi-role, expensive manned systems. Those we can afford to lose ("suicide-systems" for conventional warfare).	240, 320, 470, 480

Capability #	TFA #	TFA	Field of Science #
15	177	Improved autonomous monitoring of borders, HVAs, wide-area coverage, etc. Need research into sensors and detection algorithms.	210, 240, 450, 480
15	178	Need more research into the collaboration between man and machine. People, robots and reach-back will all be elements in future ops. How to optimise the way these operate together and communicate.	210, 240, 310, 350, 450, 480
15	179	Utilize existing (but untried / not legally cleared) technologies that enhance defensive capabilities, i.e., various non-lethal weapons: sonic, laser dazzler, electro-magnetic weapons (EMP, HPM).	480
16	180	Methods/tools to identify trust (on an intercultural dimension) and incorporate it into operational planning.	300, 480
17	181	Complexity science and cyberspace security studies.	210, 220, 240
17	182	Emphasis probably better spent on ensuring access through robustness, redundancy, protection.	240, 450
17	183	“Archaic” fallback methods (paper maps, supply forms, manual navigation aids).	210
18	184	Micro-satellites, alternative space vehicles.	450
18	185	Redundancy measures.	240, 450
18	186	Drone-based navigation and communication systems.	210, 240, 450
18	187	Smart dust and pollen to build ad hoc connectivity.	210, 450
18	188	Networked balloons and air assets.	200, 450
18	189	Protection of ground-based assets.	450, 480
18	190	Inertial systems based on N-MEMS.	210, 450
18	191	Distributed cognitive systems.	210, 240, 430
18	192	Ionosphere refraction index prediction.	112, 114

Capability #	TFA #	TFA	Field of Science #
18	193	Swarm of autonomous, networked UAVs. With advanced sensors and image/map processing these could provide navigation aid, surveillance and comms. Each of them could be small and/or specialised and hence be relatively cheap. Research areas (theoretical research, simulator trials, small-scale tests ongoing, but system is not fielded, mainly because FAA and society are not ready).	200, 450
18	194	Peer-to-peer collision avoidance.	210, 450
18	195	Image processing algorithms.	200
18	196	Collaborative/networked, but autonomous operations.	210, 470, 480
18	197	Enabling technologies: enhanced batteries (high capacity, long endurable, rechargeable).	450
19	198	Process and policy studies particularly across changing and shifting political dimensions.	360, 470, 480
19	199	Conflict management studies: alignment or miss-alignment of various national interests with a pan NATO interest.	310, 330, 340
20	200	Cross-cultural psychology studies.	310, 330
20	201	Relationship and network building: mentoring and trust versus master and servant.	300, 470, 480
20	202	Learning and info sharing.	210, 330, 430
20	203	Relationship building based on growing commonalities and less on managing differences.	300, 470, 480
20	204	Auto language translation incorporating other sensors such as gestures, body language, eye movement, etc.	210, 310, 330, 430
20	205	Auto speech to text transcription (for subsequent storage).	210
20	206	Contextual analysis and intent recognition tools.	330, 430
20	207	Social studies designed to identify and develop cultural awareness (e.g., social modelling/networking, anthropology).	310, 370

Capability #	TFA #	TFA	Field of Science #
20	208	Social studies related to how organizations and individuals can efficiently interact when they have competing goals and objectives.	310, 320, 370
20	209	Social studies related to rapidly building trust between organizations and individuals with disparate goals, cultures and objectives.	310, 320, 370
20	210	Research to identify human characteristics that build trust.	300
20	211	Training: Rapid and efficient methods.	430, 440, 480
20	212	Develop better cognitive understanding of learning.	330, 430, 440
20	213	Develop/adapt multi-player gaming to our needs (existing RTO study on application of gaming in the military?)	200
20	214	Develop training in how to interact (involving knowledge/sensitivity training about disparate cultural norms).	310, 330, 340, 470, 480
20	215	Research into complexity theory – may lead to the development of efficient ways of working together.	200
20	216	Organizational theory.	300, 240, 470
20	217	Research into alternative/efficient "management" constructs and structures (potentially involving concepts such as "focus and convergence" vice traditional C2).	300, 240, 470
20	218	Research on the efficient development, maintenance and interrogation of large knowledge bases.	200, 450
20	219	Inter-agency COP potentially supported by "Green Force Tracker," "OnStar" or GPS/Cell phone exploitation such as "Google tracking".	200, 430, 450, 470, 480
22	220	Cognitive radios and spectrum exploitation.	112, 210, 450
22	221	Bandwidth constraints and data compression.	112, 210, 220, 240, 450
22	222	Network management strategies.	240, 450

Capability #	TFA #	TFA	Field of Science #
22	223	Data-information-knowledge chain analysis in a distributed network: information needs vs. information generation vs. information location.	210, 240, 430
22	224	Studies on FMRI / polygraphs / physiological monitoring / facial change monitoring.	300, 430, 450, 460
22	225	Soft science including psychopathology and psycho sociology.	300
22	226	Man machine interface.	210, 240, 310, 350, 450, 480
22	227	Bandwidth.	112, 210, 220, 240, 450
22	228	Computational science.	210
22	229	Artificial intelligence.	210
22	230	Metadata management and labelling.	210
22	231	Tactics, techniques and procedures.	240, 470, 480
22	232	Tool development.	200, 450
22	233	Energy science and engineering.	110, 450
23	234	Organizational alignment and structure analysis.	240, 310, 470
23	235	Organizational theory.	300, 240, 470
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23	242	Data and Information management technology covering very diverse sources.	210
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24	244	Media and societal influence studies.	310, 320, 330, 370, 430
24	245	Human perceptions and heuristics studies.	330, 430
24	246	Trade-off between Info-ops, disinformation and trust and loyalty objectives in an operation.	300, 480

Capability #	TFA #	TFA	Field of Science #
24	247	Polling and surveying techniques and tools required to verify effectiveness of media strategies.	370

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Technology Focus Areas
TFAs
Thematic Analysis
Theme-Issue-Capability
TICs

14. Abstract

The NATO SAS-066 – Joint Operations 2030 Long-Term Scientific Study attempts to identify research and technology investment options that would advance and improve on future NATO capability needs in the 20 year or more time horizon. This report is a comprehensive documentation of this study effort including early discussions and assumptions; the development and application of a Thematic Analytical approach to capability definition; the iterative construction of a comprehensive set of Theme-Issue-Capability (TIC) combinations that resulted in the Joint Operations 2030 Capability Set; the refinement of this set into three sub-sets and subsequent focus on the JO 2030 List One Set of TICs; and efforts to identify potential research and technology investment opportunities which resulted in the JO 2030 List One Set of Technology Focus Areas.

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